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OF THE

New Jersey State Agricultural Experiment Station

AND THE

THIRTY-THIRD ANNUAL REPORT

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR ENDING JUNE 30

1920

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*Staff list revised to June 30, 1920.

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AND

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JOSEPH R. FRENCH, B.SC., Assistant Specialist, Fruit Growing.
MRS. CATHARINE GRIEBEL, Home Demonstration Agent.
ELSIE R. HORNE, B.SC., Assistant State Club Leader.
ARTHUR M. HULBERT, State Leader of Boys' and Girls' Club Work.
ETHEL JONES, M.A., Assistant State Club Leader.
WILLIAM F. KNOWLES, A.B., Assistant State Leader of Farm Demonstration.
A. FREEMAN MASON, M.SC., Specialist in Fruit Growing.
INGRID C. NELSON, A.B., Assistant Editor.
CHARLES H. NISSLEY, B.SC., Specialist, Vegetable Growing.
IRVING L. OWEN, B.SC., Specialist, Poultry Husbandry.
STANLEY B. ROBERTS, Assistant Specialist, Dairying.
CARL R. WOODWARD, A.M., Editor.

COUNTY EXTENSION WORKERS

County Agents

County.	*Name.*
Atlantic	ALBERT E. WILKINSON, M. AGR.
Bergen	W. RAYMOND STONE.
Burlington	FRANK B. CROSS, B.SC.
Camden	SAMUEL F. FOSTER, B.SC.
Cape May	JAMES A. STACKHOUSE, B.SC.
Cumberland	ELTON R. WAGNER, B.SC.
Essex	IRVIN T. FRANCIS, A.B.
Gloucester	LOUIS A. COOLEY, B.SC.
Mercer	WILLIAM S. BARNHART, B.SC.
Middlesex	ORLEY G. BOWEN, B.SC.
Monmouth	ELLWOOD DOUGLASS. M. ROBERT TRIMNELL, B.SC., Assistant.
Morris	BERTIN E. ELY, B.SC.
Ocean	ERNEST H. WAITE.
Passaic	HAROLD E. WETTYEN, B.SC. AMOS H. SAXE, B.SC., Assistant.
Salem	JOHN C. CRISSEY, B.SC.
Somerset	HARRY C. HAINES.
Sussex	H. E. BALDINGER, B.SC.
Warren	WILLIAM A. HOUSTON.

Home Demonstration Agents

County.	*Name.*
Bergen	CAROLYN F. WETZEL.
Essex	EUGENIE B. HUCKEL.
Mercer	EDITH M. RULIFSON, B.SC.
Middlesex	FRANCES WHITCOMB, B.SC.
Monmouth	HELEN G. BISHOP, B.SC.
Morris	CORA A. HOFFMAN, B.SC.
Passaic	MARGARET H. HARTNETT, B.SC.
City of Paterson	MRS. CECILIA BROGAN.

County Club Leaders

County.	*Name.*
Camden	*GEORGE B. FINE, A.B.
Cape May	*JOSEPH MURPHY, LL.B.
Cumberland	E. A. HOWARD.
Hunterdon	*R. SHERMAN THARP.
Mercer	JOSEPH B. TURPIN, B.SC.
Monmouth	HAROLD J. KRAUSE.
Morris	HAROLD S. WARD, B.SC.
Ocean	MRS. LYDIA GARNAR SALVADOR.
Salem	*S. T. WHEAT, B.SC.
Warren	HOWARD MASON, B.SC.

*On part time.

Letter of Transmittal

To His Excellency, Edward I. Edwards, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the Forty-First Annual Report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10, 1880, and which is chapter 106 of the laws of that year.

JAMES NEILSON,
President.

NEW BRUNSWICK, N. J., JULY 31, 1920.

To His Excellency, Edward I. Edwards, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2, 1887, and with an act of the Legislature of this State approved March 5, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey, maintaining Rutgers Scientific School, the New Jersey State College for the benefit of Agriculture and Mechanic Arts, the Thirty-third Annual Report of the operations of the department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

W. H. S. DEMAREST,
President.

NEW BRUNSWICK, N. J., JULY 31, 1920.

Treasurer's Report

Irving E. Quackenboss, in account with the New Jersey State Agricultural Experiment Station, July 1st, 1919, to June 30th, 1920.

Appropriation for Salaries, Wages and Maintenance

Appropriation	$45,000.00
Allotment from Emergency Fund	6,000.00
Collections from Dairy, Swine, etc.	20,005.65
	$71,005.65

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$37,656.22
Bills submitted to State Comptroller for direct payment—	
Books and Periodicals	285.45
Coal	1,457.50
Drilling Well	484.00
Electric Current and Gas	1,194.59
Express, Freight and Cartage	1,013.98
Fair Exhibits and Field Day Expenses	687.70
Feed and Shavings	12,506.91
Fertilizer	93.75
Hardware, Tools, etc.	334.97
Laundry Work	113.77
Miscellaneous Hour and Day Labor	2,546.26
Office Furniture and Equipment	162.63
Orchard Supplies	895.56
Photographic Supplies	99.10
Postage	773.56
Registration of Animals	71.00
Repairs and Alterations to Buildings	1,904.01
Repairs to Equipment	194.37
Scientific Equipment	399.66
Scientific Supplies	247.82
Small Printing and Stationery	1,200.94
Team Hire	162.00
Telephone and Telegraph	1,316.64
Traveling Expenses	4,299.94
Trees, Seeds and Vines	43.00
Veterinary Services and Medicine	350.74
Water and Ice	87.33
Sundries	73.35
	$70,656.75
Amount reserved by requisition until next fiscal year	79.21
Amount reverting to State Treasury	269.69
Total	$71,005.65

Appropriation for Printing Bulletins and Circulars

Appropriation	$7,000.00

PAYMENTS

Bills submitted to State Comptroller for direct payment—	
For Printing Bulletins and Circulars	$6,999.51
Amount reverting to State Treasury	.49
Total	$7,000.00

Appropriation for Abolishing Mosquito Breeding Salt Marshes

Appropriation	$15,000.00

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$5,995.82
Bills submitted to State Comptroller for direct payment—	
Advertising	55.64
Express, Freight and Cartage	5.49
Field Supplies	162.39
Field Work-Ditching and Building Sluices	6,430.00
Miscellaneous Hour and Day Labor	93.00
Office Furniture and Equipment	94.14
Photographic Supplies and Blue Prints	32.52
Postage	50.00
Repairs to Office Equipment	1.00
Scientific Equipment	281.70
Telephone and Telegraph	35.60
Traveling Expenses	1,704.57
	$14,941.87
Amount reverting to State Treasury	58.13
Total	$15,000.00

Appropriation for the Investigation of Oyster Propagation

Appropriation	$900.00
Collections from Sale of Boat	18.00
	$918.00

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$430.00
Bills submitted to State Comptroller for direct payment—	
Express, Freight and Cartage	3.32
Insurance	33.60
Oyster Laboratory Supplies	71.12
Photographic Supplies	38.76
Repairs to Oyster Laboratory Equipment	189.07
Traveling Expenses	98.11
	$863.98
Amount reverting to State Treasury	54.02
Total	$918.00

Appropriation for the Department of Poultry Husbandry

Appropriation	$12,000.00
Collections for Sales of Poultry and Eggs	11,331.94
	$23,331.94

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$10,887.50
Bills submitted to State Comptroller for direct payment—	
Coal	578.80
Dog Cakes	27.00
Horse	125.00
Miscellaneous Hour and Day Labor	222.30
Office Furniture and Equipment	617.93
Poultry Feed	7,779.11
Poultry Supplies and Tools	268.71
Repairs and Alterations to Buildings	879.73
Scientific Equipment	892.17
Scientific Supplies	14.75
Small Printing and Stationery	138.50
Traveling Expenses	863.14
Trees, Seeds and Vines	27.50
	$23,322.14
Amouut reverting to State Treasury	9.80
	$23,331.94

Appropriation for Seed Inspection

Appropriation	$5,000.00

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$3,660.00
Bills submitted to State Comptroller for payment—	
Miscellaneous Hour and Day Labor	75.60
Office Furniture and Equipment	342.45
Photographic Supplies	20.00
Postage	100.00
Scientific Equipment	192.17
Small Printing and Stationery	174.90
Telephone	.65
Traveling Expenses	371.13
Sundries	5.00
	$4,941.90
Amount reverting to State Treasury	58.10
Total	$5,000.00

Appropriation for Experimental Work in Vegetable Production

Appropriation	$2,500.00
Collections for Sales of Vegetables and Flowers	2,475.58
	$4,975.58

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$1,840.00
Bills submitted to State Comptroller for direct payment—	
Coal	900.00
Express, Freight and Cartage	35.00
Greenhouse Supplies and Tools	230.50
Horse	225.00
Miscellaneous Hour and Day Labor	302.98
Repairs and Alterations to Building	407.96
Scientific Equipment	462.00
Scientific Supplies	105.50
Traveling Expenses	335.99
	$4,844.93
Amount reverting to State Treasury	130.65
Total	$4,975.58

Appropriation for Insecticide Inspection

Appropriation	$1,000.00

PAYMENTS

Bills submitted to State Comptroller for direct payment—	
Chemical Supplies	$484.53
Scientific Apparatus	361.27
	$845.80
Amount reserved by requisition until next fiscal year	153.60
Amount reverting to State Treasury	.60
Total	$1,000.00

Appropriation for Farm Demonstration

Appropriation	$40,000.00

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$38,693.56
Bills submitted to State Comptroller for direct payment—	
Miscellaneous Hour and Day Labor	47.31
Postage	204.43
Printing Extension Bulletins and Circulars	467.15
Small Printing and Stationery	92.31
Telephone and Telegraph	1.55
Traveling Expenses	493.69
Total	$40,000.00

Appropriation for Cranberry Investigation

Appropriation	......
Allotment from Emergency Fund	$2,000.00
	$2,000.00

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$1,166.68

Bills submitted to State Comptroller for direct payment—	
Field Supplies	$2.85
Miscellaneous Hour and Day Labor	182.80
Scientific Equipment	56.21
Telephone and Telegraph	3.65
Traveling Expenses	571.58
	$1,983.77
Amount reverting to State Treasury	16.23
Total	$2,000.00

Appropriation for Egg-Laying and Breeding Tests

Appropriation	$4,500.00

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$4,260.00
Bills submitted to State Comptroller for direct payment—	
Miscellaneous Hour and Day Labor	37.50
Traveling Expenses	197.54
	$4,495.04
Amount reverting to State Treasury	4.96
Total	$4,500.00

Appropriation for Experimental Work in Growing White Potatoes, Sweet Potatoes and Tomatoes

Appropriation	......
Allotment from Emergency Fund	$3,000.00
	$3,000.00

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$2,200.00
Bills submitted to State Comptroller for direct payment—	
Express, Freight and Cartage	38.45
Field Supplies	48.16
Miscellaneous Hour and Day Labor	156.85
Telephone and Telegraph	6.00
Traveling Expenses	459.64
	$2,909.10
Amount reverting to State Treasury	90.90
Total	$3,000.00

Appropriation for Repairs to Experiment Station Building

Appropriation	$800.00

PAYMENTS

Bills submitted to State Comptroller for direct payment—	
Repairs to Experiment Station Building	799.06
Amount reverting to State Treasury	.94
Total	$800.00

Concentrated Commercial Feeding Stuffs

Appropriation-Collection of Feed Inspection Fees	$20,692.88

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$8,716.20
Bills submitted to State Comptroller for direct payment—	
Books and Periodicals	8.50
Feed and Shavings	7,462.34
Hardware, Tools, etc.	494.06
Insurance	25.00
Miscellaneous Hour and Day Labor	487.45
Office Furniture and Equipment	202.07
Photographic Supplies	22.00
Postage	313.00
Repairs and Alterations to Buildings	495.70
Repairs to Equipment	70.31
Scientific Equipment	171.55
Scientific Supplies	440.50
Small Printing and Stationery	979.92
Traveling Expenses	135.66
Trees, Seeds and Vines	511.10
Water and Ice	42.11
Sundries	59.83
	$20,637.30
Amount reverting to State Treasury	55.58
Total	$20,692.88

Fertilizer Inspection Fees

Appropriation-Collection of Fertilizer Inspection Fees	$22,088.06

PAYMENTS

By Treasurer of the Experiment Station—	
Salaries and Wages	$8,831.74
Bills submitted to State Comptroller for direct payment—	
Electric Current and Gas	422.23
Express, Freight and Cartage	116.64
Feed and Shavings	5,088.41
Fertilizer	2,828.32
Hardware	.75
Horses	800.00
Laundry Work	86.69
Miscellaneous Hour and Day Labor	466.83
Office Furniture and Equipment	10.00
Photographic Supplies	17.48
Postage	23.77
Registration of Animals	25.00
Repairs and Alterations to Buildings	7.17
Repairs to Equipment	111.88
Small Printing and Stationery	6.27
Telephone and Telegraph	590.41
Team Hire	54.00
Traveling Expenses	2,050.29
Veterinary Services and Medicine	98.52
Sundries	11.83
	$21,648.23
Amount reverting to State Treasury	439.83
Total	$22,088.06

Bonus Account

Experiment Station Share of Appropriation	$5,692.30

PAYMENTS

By Treasurer of the Experiment Station—	
Bonus to Employes covering First Half of Bonus for the Year 1919-1920	$5,692.30

SUMMARY

Total Appropriations	$133,700.00
Total Allotments from Emergency Fund	11,000.00
Total Collections Credited to Appropriations	76,612.11
Experiment Station Share of Bonus Appropriation	5,692.30
Total	$227,004.41

Summary of Analysis of all Expenditures

Advertising	$55.64
Books and Periodicals	293.95
Coal	2,936.30
Drilling Well	484.00
Electric Current and Gas	1,616.82
Express, Freight and Cartage	1,212.88
Fair Exhibits and Field Day Expenses	687.70
Feed and Shavings	32,863.77
Fertilizers	2,922.07
Hardware, Tools, etc.	1,328.99
Horses	1,150.00
Insurance	58.60
Laundry Work	200.46
Miscellaneous Hour and Day Labor	4,618.88
Mosquito Field Work-Ditching and Building Sluices	6,430.00
Office Furniture and Equipment	1,429.22
Orchard Supplies	895.56
Photographic Supplies	229.86
Postage	1,464.76
Printing Bulletins and Circulars	7,466.66
Registration of Animals	96.00
Repairs and Alterations to Buildings	4,493.63
Repairs to Equipment	566.63
Salaries and Wages	124,337.72
Scientific Equipment	2,816.73
Scientific Supplies	1,577.62
Small Printing and Stationery	2,592.84
Team Hire	216.00
Telephone and Telegraph	1,954.50
Traveling Expenses	11,581.28
Trees, Seeds and Vines	581.60
Veterinary Services and Medicine	449.26
Water and Ice	129.44
Sundries	150.01
Bonus to Employes covering first half of Bonus year, 1919-1920,	5,692.30
	$225,581.68
Amount reserved by requisition until next fiscal year	232.81
Amount reverting to State Treasury	[illegible]

Collections Account

RECEIPTS

From Dairy Department—	
Collections for Sales of Milk, Cream and Dairy Stock, Glassware Tested, and Milk Testers' Licenses Issued	$13,408.46
From Swine Department—	
Collections for Sales of Swine	3,877.20
From Horticulture Department—	
Collections for Sales of Peaches, Trees, Surplus Sugar and Second Hand Orchard Equipment	2,293.99
From Agricultural Department—	
Collections for Sales of Honey	426.00
From Oyster Propagation Department—	
Collections for Sale of Boat	18.00
From Poultry Department—	
Collections for Sales of Poultry and Eggs	11,331.94
From Vegetable Gardening Department—	
Collections for Sales of Vegetables	1,442.30
From Floriculture Department—	
Collections for Sales of Flowers	1,033.28
From Chemical Department—	
Collection of Feed Inspection and Registration Fees......	20,692.88
From Chemical Department—	
Collection of Fertilizer Inspection and Registration Fees..	22,088.06
From National Bank of New Jersey—	
For Interest on Deposits	73.63
Total	$76,685.74

PAYMENTS

To State Treasurer—	
Collections for Sales of Milk, Cream and Dairy Stock, Glassware Tested, and Milk Testers' Licenses Issued......	$13,408.46
To State Treasurer—	
Collections for Sales of Swine	3,877.20
To State Treasurer—	
Collections for Sales of Peaches, Trees, Surplus Sugar and Second Hand Orchard Equipment	2,293.99
To State Treasurer—	
Collections for Sales of Honey	426.00
To State Treasurer—	
Collections for Sale of Boat	18.00
To State Treasurer—	
Collections for Sales of Poultry and Eggs	11,331.94
To State Treasurer—	
Collections for Sales of Vegetables	1,442.30
To State Treasurer—	
Collections for Sales of Flowers	1,033.28

To State Treasurer—	
Collection of Feed Inspection and Registration Fees.......	$20,692.88
To State Treasurer—	
Collection of Fertilizer Inspection and Registration Fees..	22,088.06
To State Treasurer—	
For Interest on Deposits	73.63
Total	$76,685.74

The Auditing Committee of the Experiment Station has examined the Accounts of the Treasurer of said Station, and has found them correct.

(Signed) WM. H. REID,
EGBERT T. BUSH,
Auditing Committee.

Financial Statement

TRUSTEES OF RUTGERS COLLEGE FOR THE NEW JERSEY STATE AGRICULTURAL COLLEGE EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION, 1919-1920.

Dr.	*Hatch Fund*	*Adams Fund*
To Receipts from the Treasurer of the United States as per Appropriations for Fiscal Year Ended June 30th, 1919, Under Acts of Congress Approved March 2d, 1887 (Hatch Fund), and March 16th, 1906 (Adams Fund)........	$15,000 00	$15,000 00
Abstracts	*Hatch*	*Adams*
Salaries	$9,599 98	$10,836 08
Labor	1,875 07	973 42
Publications	203 68	....
Postage and Stationery	265 02	65 32
Freight and Express	23 43	38 95
Heat, Light, etc.	....	10 55
Chemicals and Laboratory Supplies..................	305 76	569 51
Seeds and Plants	406 42	454 56
Fertilizers	3 92	3 13
Feeding Stuffs	....	360 00
Library	52 15	117 70
Tools, Machinery, etc.	66 15	252 05
Furniture and Fixtures	180 77	35 26
Scientific Apparatus	40 60	112 00
Live Stock	....	250 00
Traveling Expenses	1,627 21	....
Contingent Expenses	....	4 75
Buildings and Land	349 84	750 00
Balance	....	166 72
	$15,000 00	$15,000 00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the New Jersey State Agricultural College Experiment Station for the fiscal year ended June 30th, 1920; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was $........ on the Hatch Fund and $........ on the Adams Fund; that the receipts for the year from the Treasurer of the United States were $15,000.00 under the act of Congress of March 2d, 1887, and $15,000.00 under the act of Congress of March 16th, 1906, and the corresponding disbursements of $15,000.00 and $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving balances of $........ and $166.72.

And we further certify that the expenditures have been solely for the purpose set forth in the acts of Congress approved March 2d, 1887, and March 16th, 1906, and in accordance with the terms of said acts, respectively.

(Signed) W. H. S. DEMAREST,
J. G. LIPMAN,
Auditors.

REPORT OF THE DIRECTOR

Report of the Director

JACOB G. LIPMAN, PH.D., *Director*

LINDLEY G. COOK, B.SC., *Assistant to the Director*

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Report of the Director

JACOB G. LIPMAN

More intensive methods and specialization in cropping still continue to be a feature in the agricultural development of New Jersey. Apples, peaches, potatoes, sweet potatoes, tomatoes, cranberries, beans, peas and miscellaneous vegetables are receiving an increasing amount of attention. In the livestock industry dairymen and poultrymen are confronted by very important problems. New questions are constantly arising in the fields of production, transportation and distribution, as well as in the less clearly defined field of community life.

In all of these fields the Experiment Station has directly or indirectly certain responsibilities. In its immediate contact with a large constituency, or through its cooperation with the State Agricultural College, the federal and state departments of agriculture and with the other state institutions and agencies, it must seek to throw light on many perplexing questions. It must deal with an almost unending number of problems that concern soils, fertilizers, crops, insects and diseases. Livestock and livestock management, livestock diseases, farm buildings, farm machinery and farm management all call for consideration. Samples of fertilizers, lime, feeding stuffs, insecticides, fungicides, seeds and inoculants must be examined and analyzed for the protection of the purchaser. Educational activities by means of farm bureaus, home demonstration, boys' and girls' clubs and extension specialists must be maintained and developed. And, above all, the agriculture of the state must be studied in its broad relations; and its needs, its opportunities and its future regarded from the point of view of the men and women to whom it offers a home and living, as well as from the point of view of the consumer in the city to whom a supply of food, ample as to quantity, wholesome as to quality and reasonable as to cost, is a matter of vital concern.

Resources and Service

In the last analysis the members of the staff of any educational institution are its chief resources. In so far as they have ability and vision, the work entrusted to their care must make progress. Their failure means also the failure of the service for which they are responsible. It is fortunate for the Station that most of the men holding responsible positions in the institution have remained in the service in spite of the economic pressure and the attractive offers that have come to some of them from commercial or other sources. Gradually the research and other activities of the institution are becoming normal again. The lines are being more sharply drawn between the needs of research and of agricultural extension. Each is being strengthened, both at New Brunswick and in the counties of the state.

Serious concern is being felt on account of the failure of our colleges and universities to interest their graduates in preparing themselves for investigational work. The young men now graduating from our colleges seem to feel that the opportunities in industrial and commercial fields are much more attractive than they are in the educational field. Hence, for some years to come the need will be felt more and more strongly for young men of suitable ability and training to carry on the research activities of our experiment stations. It is hoped that everything will be done to meet the situation. The establishment of research assistantships, opportnnities for carrying on graduate study and more adequate compensation for those who have been able to demonstrate their ability as investigators should again help to interest young men in experiment station research as a career.

Aside from the trained men as the major factor in the progress of the station activities, there is the important factor of physical resources. These consist of land, buildings and equipment. The New Jersey Station is fortunate in being able to carry on investigations of a varied nature both at New Brunswick and outside in the state. Rather extensive fertilizer and other experiments are being carried on with cranberries and blueberries in Burlington County. A large number of experiments concerning the different phases of potato growing are in progress both in southern and central New Jersey. Similar experiments with tomatoes, sweet potatoes, peaches, apples, celery, corn and alfalfa are in progress in different parts of the state. Livestock problems, particularly those relating to the dairy, swine and poultry industries, are receiving careful study. It may be said, therefore, that the Experiment Station has physical resources much larger than those provided by the buildings, land and equipment at New Brunswick.

As the agricultural problems change, as the need for new types of study develops, the location of experimental work in the state may change from time to time and may very nicely supplement the experimental work at New Brunswick.

During the year just past substantial additions have been made to the physical resources of the institution. The Horticultural Building now being constructed will be available for station as well as college activities. It is expected that the Horticultural Building will be completed and ready for occupancy at the beginning of 1921. The poultry plant at the College Farm has been made more adequate for the investigational activities of the department by the fencing in of an additional area of three acres to be used as a range for the growing stock. Several new colony houses were added to the equipment of the animal husbandry department. A farm adjoining the Horticultural Farm has been leased for use by the pomological and vegetable gardening divisions of the department. This farm consists of 23 acres and has buildings which have been made available for use by the horticultural department. It is planned to enclose about 150 acres of land, part of it cut-over woodland, and to convert it into pasturage for dairy stock. With the increasing size of the herd as well as the increasing cost of labor and forage, the pasture should materially help in reducing the cost of milk production and in the further developing of the college and station herd.

Together with the State Agricultural College, the Experiment Station is badly handicapped by lack of laboratory and office space. On account of the high cost of construction the Horticultural Building as erected will be much smaller than that originally planned. The dairy department is badly in need of classrooms and laboratories for experimental work in dairy bacteriology and chemistry, as well as for classroom and laboratory instruction. The same is true of the poultry department, of the farm economics department and of the department of soils and crops. The growth of the extension service at the institution is constantly calling for more office space and in time it will be desirable to have a building suitable for housing the extension division of the service. The storage facilities for hay, fertilizers, feeding stuffs and farm machinery and implements are quite inadequate. In fact, a storage building is one of the most pressing needs of the Station. A building of this character would permit the purchase of supplies at a time of the year when the prices are lowest. It would also provide protection for farm wagons and machinery, much of which must now be kept out in the open.

Additional equipment as to farm machinery and implements to be made available both for experimental and instructional purposes, and the purchase of one or two motor trucks that might serve both the Station and the College may be recommended. The securing of ad-

ditional specimens of swine, sheep and dairy and beef cattle would be desirable for the sake of completing the livestock resources of the institution both for experimental and educational purposes.

During the year a number of minor changes and additions have been made at the Station. One of the dairy buildings has been remodeled and is now in a very acceptable condition for the carrying on of experiments on the growing of dairy stock. The dwelling house at the Horticultural Farm has been repaired both inside and out. Repairs were also made in the dwelling at the Dairy Farm, and fences and gates have been constructed to facilitate the handling of the dairy animals. During one of the severe storms in July a large hay barn, formerly available for the storing of 80 to 100 tons of hay, was blown down, and it became necessary promptly to provide storage facilities for that quantity of hay. A barrack was erected at the College Farm and most of the timothy and mixed hay placed under cover. An addition is also being built to the Soil House in order that the space for storing soil and crop samples be increased and other facilities for soil investigation be provided.

New Legislation

A number of acts passed during the legislative session of 1920 have materially widened the scope of the activities of the Station. An act providing for the inspection of dairies and milk stations purchasing milk or cream on the butterfat basis has been passed. This act takes the place of an older enactment. It carries an appropriation of $3,000 per annum, an amount sufficient for the time being for engaging the services of a creamery inspector and for paying his traveling expenses and for arranging for suitable examinations for those who serve in the capacity of testers at creameries and milk stations.

Two laws of interest to the poultry industry also were enacted. One of these extends the scope of the Egg-Laying and Breeding Contest and provides for the location of an additional contest and breeding station in Bergen County in 1920 and for still another one in central New Jersey in 1921. Wide interest has been aroused in Bergen county in the establishment of the egg-laying and breeding station. Local funds amounting to more than $16,000 have been raised to supplement the state appropriation of $5,000. A suitable site has been secured and the station will be ready to take up its activities in the fall.

Another act, providing for the organizing and carrying on of poultry exhibits and the awarding of prizes at poultry shows, has become a law. Also this act is of interest to poultrymen all over the state, in that it will encourage the improving of the breeds of poultry as well as the introduction of more progressive methods of poultry

management. Still another law was enacted relating to the study of sewage disposal and sewage purification. The State Board of Health and the State Experiment Station have been authorized, when funds are appropriated for the purpose, to study the bacteriology and chemistry of sewage disposal. Funds have been appropriated for enforcing the inspection of legume inoculants. Arrangements have already been made to collect samples of cultures sold in the state for the inoculation of legumes and to examine these for purity and effectiveness.

DEPARTMENT ACTIVITIES

Chemistry

The activities of the department of chemistry for the fiscal year ending June 30, 1920, have been confined to the inspection work as prescribed by the laws regulating the sale of fertilizers, agricultural lime, insecticides and feeding stuffs.

During the year three members of the staff resigned and, although their successors were appointed as soon as possible, the work was interfered with for a time. The inspections were completed, however, without serious delay and this condition was due to the manner in which each member of the staff looked after the work assigned to him.

The inspections required the examination of 2,146 samples and the reports were submitted to the manufacturers as well as to the parties whose stock was represented by the samples. In order to render these reports it was necessary to make about 18,000 separate determinations. The detailed results of the inspections appear in five bulletins published by the Station during the year.

Inspection of Commercial Fertilizers

Registrations of 1,540 brands of mixed fertilizers and fertilizer materials were made by 130 manufacturers and jobbers and the tonnage reported on April 1, 1919, and November 1, 1919, amounted to 138,058.04 tons of mixed fertilizers and 11,427.01 tons of fertilizer materials, making a total of 149,485.05 tons.

The samples analyzed during the year consisted of the following:

556 samples of commercial fertilizers
109 samples of commercial fertilizers (duplicates)
8 samples of home mixtures
11 samples of humus and manures
127 samples of fertilizer materials
40 samples of ground bone
234 samples of sundry materials

The average composition of the samples of mixed fertilizers examined was substantially equal to the guarantees given—the average content of nitrogen being somewhat less and the average content of phosphoric acid and potash larger than the average guarantees. The detailed records show that 130 brands fully sustained their guarantees, and that 258 brands were substantially in the same class. There were 168, or 30 per cent, deficient brands, 149 being deficient in one element, 18 in two elements and 1 in the three elements.

Inspection of Agricultural Lime

During the year 35 manufacturers registered 72 different brands of agricultural lime. A comparatively large number of samples of the lime was received and duly reported.

Inspection of Insecticides

Two hundred and eleven brands were registered by 47 manufacturers and jobbers. The chemical work consisted of the examination of the following:

15 samples of paris green
7 samples of lead arsenate (paste)
20 samples of lead arsenate (powder)
10 samples of bordeaux mixture
6 samples of lime-sulfur solution
5 samples of soluble sulfur compounds
4 samples of nicotine preparations
33 samples of miscellaneous brands

Inspection of Commercial Feeding Stuffs

There were 2,507 brands of feeding stuffs registered by 420 manufacturers and jobbers during the year and the total amount sold was 246,889.49 tons. During the inspection a total of 935 samples were examined.

From the examination of the official samples it was found that 171, or 20.8 per cent, did not substantially satisfy the guarantees given for protein, fat and fiber. The deficiencies found consisted of the following: protein 68, fat 59, and fiber 78. There were 141 samples deficient in one nutrient, 28 deficient in two nutrients and 2 deficient in the three nutrients. The New Jersey manufacturers are credited with 189 brands and of this number 53, or 28 per cent, are deficient. The number of deficient samples representing shipments from other states is 118, or 18.6 per cent.

Horticulture

Pomology

The work at the Vineland orchard was continued throughout the growing season of 1919, but, in view of the fact that the experimental work was practically completed, the orchard was turned over to the Training School at Vineland on January 1, 1920. The effect of this orchard upon the peach industry of New Jersey cannot be measured, but it has been a very important factor in connection with the rapid development of peach growing in the southern part of the state during the past ten years. With the Vineland project discontiuued, the peach breeding work at New Brunswick becomes the major fruit project. The fruits from over 650 trees were studied and described during the year, 66 of which were considered worthy of further trial.

The apple-pruning experiment at New Brunswick is just beginning to produce definite results, all varieties having produced some fruit. In every case the "unpruned" trees produced the largest number of apples, with the "winter-pruned but not-cut-back" second and the "winter-pruned and cut-back" third.

Vegetable Gardening

The work in vegetable gardening has progressed rapidly during the past year. Rather extensive fertilizer experiments with tomatoes, started in the spring of 1919, were continued and extended in 1920. The range of greenhouses formerly used for experimental work in floriculture is now entirely devoted to work in vegetable production.

Floriculture

The floricultural work, reduced to a minimum during the war, is being continued on a limited scale, the work in carnation breeding being the major project.

Animal Husbandry

One experimental project was started in the animal husbandry department during the summer of 1919. This was a comparison of fish meal with digester tankage as a source of protein supplementing the grain diet. Owing to the illness of the assistant animal husbandman and the herdsman, some mistakes were made in the latter part of the experiment and the figures were questionable. Up to this time, however, there was comparatively little difference in the two lots of pigs as to feed consumed and gain in weight.

A record was kept of the amount of cured alfalfa hay which was cut from the plot that was seeded in August, 1917, and had been used for forage for the two succeeding years. Three cuttings were secured, but the crop was killed out during the winter as a result of the pigs being left on it too late and the severity of the winter.

The herd at the present time includes the two breeds which are found most in New Jersey, namely, the Duroc-Jersey and Berkshire. The herd consists of 25 breeding animals and 65 spring pigs, these being used for experimental work. They will be marketed in the fall. Eleven sows are due to farrow during August and September. These pigs will be carried through the winter and sold in the spring.

The department should have adequate buildings for sheep and beef cattle and a flock and herd of these classes of livestock, so that students would be given a more thorough training in the care and management, and that experimental work could be carried on that would aid the farmer to utilize the by-products of some specialized branch of agriculture and provide cheap food under eastern conditions.

Poultry Husbandry

The work of the department of poultry husbandry during the past year has increased very materially. The after-war impetus which has been apparent in the poultry industry throughout the country has been very keenly felt in New Jersey. In a way this has been measured by the increased calls upon the staff for help and advice. The personnel of the department has been somewhat reorganized, due to certain resignations, the appointment of new members and the return of some from army service. Under the present organization the department is planning larger and more extensive projects for the coming year.

Since the signing of the armistice the general nature of the work undertaken by the department has been somewhat changed. Several important research projects temporarily discontinued during war-times have been revived. One of the most important lines of research work has been the continuation of investigations along the line of ascertaining the effect of quality and quantity of rations upon egg production. A particularly interesting phase of this work has been the carrying through of 19 pens consisting of 50 Leghorn pullets in which series different proportions of mash and grain, as well as different percentages of meat scrap, have been tested. Great stress has been laid upon the importance of feeding pullets properly during the few weeks in the fall prior to their coming into full laying condition. This process of finishing the pullets is considered one of paramount importance to the poultryman. Closely related to these feeding investigations have been attempts to study ways and means

f using artificial illumination for producing flocks. The general esults have pointed out quite clearly that a long working day during he winter months caused a heavier food consumption and a conseuent heavier egg production. This line of work points undoubtedly oward a system of management that must be recognized as one of fficiency and economy when properly handled.

A vast amount of data has been collected concerning poultry breedng work. Not only have the trap-nesting and pedigreeing projects een continued at the farm at New Brunswick, but the Vineland Egg-aying Contest likewise has furnished unlimited material for the study f breeding principles. The ultimate end of studying this line of vork is to build up a type of poultry than can and will use food tuffs more efficiently. A great many pedigreed Leghorn cockerels rom the Belle of Jersey strain have been sold to poultrymen of the tate and in each case an effort has been made to stimulate interest n the continuance of accurate record keeping.

The importance of developing and maintaining the health of oultry flocks has been appreciated, extensive observations have been onducted on the distribution and prevalence of poultry diseases in he state. A detailed account of the results of these observations vill be found in the report of the poultry husbandman in the followng pages. Considerable time and thought have been expended in tudying the control of chicken pox, roup and canker. It is felt that eadway has been made in this line of investigation. It is a tremenlous problem and will require the expenditure of much time and ffort before definite practical methods of control can be formulated. During the summer of 1920 extensive experiments are being conlucted along this line.

The research activities of the department are to be greatly enlarged luring the coming year by the operation of a second egg-laying conest and breeding station, located in Bergen County. In addition to his a project has been started to increase interest in the breeding of tandard-bred poultry through the supervision of poultry exhibitions, he holding of educational programs and exhibits and offering of oremiums. This project is in accordance with a law passed by the ecent Legislature. The results of the research work done in the deartment have been widely distributed through the continuance of the oublication of "Hints to Poultrymen" each month. It will be the ontinued policy of the department to publish these circulars for listribution among the poultry raisers of the state. News notes and educational bulletins have gone out frequently during the year, calling attention to seasonable points and practices that might aid poultrymen in general.

The extension work of the department is increasing daily in quantity. Many visits have been made by the extension specialist as well as other members of the departn

It is felt that during the past year the poultry industry of the state has enjoyed a healthy and vigorous growth. It is the policy of the department to render any service possible that may tend to keep this well established field of agriculture in a growing condition.

Dairy Husbandry

The activities of the department of dairy husbandry for the year ending June 30, 1920, may be listed as follows.

Experimental

Data have been gathered on five different experimental projects.

Extension

The department of dairy husbandry, cooperating with the department of extension, has given advice and assistance to the dairymen of the state through meetings, correspondence and personal visits. Six separate projects have been carried on. The bull association work and the work of establishing local breeders' clubs has been exceptionally successful.

Advanced Registry

The advanced registry work has developed to such an extent that a great amount of work is required to supervise it efficiently. There has been an increase of 53 per cent in this work over the preceding year. The number of separate tests supervised was 2,152, and 796 records were completed. During the year ending June 30, 1919, 1,366 tests were made and 520 records were completed.

There has been a marked increase in the amount of semi-official work being done.

Creamery Inspection

The year has seen this work carried on as vigorously as limited funds and the limited authority delegated by the law would permit. Four cases were brought and successfully prosecuted against firms violating provisions of this act.

A new law carrying an adequate appropriation and adequate powers for enforcement becomes effective July 1, 1920. It is hoped that this department will be able to render better service to the farmers of New Jersey during the coming year.

Seed Control

It is believed that the services which the seed laboratory has rendered during the past year have done much to place it before the public and to establish its existence in a definite manner. There has been an increasing demand in analytical work and a specific interest in seed quality has been shown by repeated inquiries into production, distribution and selection. Every possible effort will be made to maintain this beneficial development.

There has been a continual increase in the numbers of samples received from farmers and merchants of the state. These are classified as unofficial samples and mark the tenor of efficiency and the result of careful information forwarded in purity and germination reports. The samples represent many lots of seed which are bought or rejected on the basis of laboratory reports. They obviously vary in kind and quality as they are selected from various lots of seeds in different localities of the state. In general, it may be stated that such samples show an average fair quality.

The official samples have been more limited, than would seem desirable for the most effective operation of the law. However, more lots have been inspected during this year than in previous years. The advisability of a thorough inspection cannot be too strongly urged, for the operation of the law and the subsequent surety of enforcement is dependent almost wholly upon this feature. It seems imperative that the inspection be conducted by an individual whose undivided interests are focused upon that liue of endeavor. It is very probable that, with the funds available at the present time, a more satisfactory arrangement for inspection can be made in the future. Although a number of lots of seeds sampled by inspectors have been manifestly inaccurately labelled, it is also worthy of note that the percentage is much smaller than formerly. The insistent demands made by the farmer for seeds of a better quality, and his knowledge of the points of the law, have forced an accurate statement of purity and germination.

Special study has been given the imported seed situation. During the past year large shipments have come in from abroad. Many samples have been examined with a view to establishing their origin; that is, whether they are foreign or American-grown seed. In consequence, factors which demonstrate the identity of foreign seed have been determined. This facilitates the advisory capacity of the seed laboratory in such matters.

Agricultural Extension

The outstanding feature of extension work during the past year has been the change from the war emergency basis to permanent peace basis. During the war funds were made available through

appropriations by Congress, and with the use of these funds emerge demonstration agents were employed and placed in several count of the state and in some of the cities. No effort has been made continue the city work. The Smith-Lever Act clearly contempla that the work done under that act should be for rural people, a we have, therefore, devoted our funds almost exclusively to the dev opment of the rural work. The exception to this is in the City Paterson. Through the interest of the Chamber of Commerce and schools, an appropriation was secured for cooperation with the tension division in the employment of a city demonstration age We have limited our support to that work to $600 per year, the ditional funds required being made available through appropriati by the city government.

The county work which was started during the war has all be maintained on a permanent peace basis, and additional counties ha come in for cooperation. This addition has without doubt come ab through the fact that emergency agents were not placed in count unless the county gave some financial support to the work. T local support even of an emergency measure resulted in winning t interest of the people of the county to this work, and this inter was so great that the people of the counties themselves desired maintain the work permanently.

On July 1, 1920, 18 county agents are employed, 8 home demonst tion agents, and 6 county club leaders, all giving full time to the wo and being employed cooperatively by the United States Departme of Agriculture, the State Agricultural College, and the county which they are located. In all of this work we are recognizing t county board of agriculture as our county-wide cooperating age This recognition of the county board does not in any way prevent o cooperating with other associations, as the grange and farmers' clu but in the matter of finance and in submitting the budget to t county boards of freeholders, the county board of agriculture is reco nized as being the official cooperating organization in the support the work. With the organization of a State Council of County Boar of Agriculture, and with increased membership in the county boar which will probably result from this state federation, we feel th additional strength will come to the work through this cooperation.

Specialists

Specialists are employed in the following subject-matter line dairy husbandry, fruit growing, vegetable gardening, poultry, soi and crops, clothing.

Each subject-matter specialist is charged with the responsibilit of seeing that extension work in his particular subject-matter is o ganized and carried out in the various counties in the best manne

ɔssible to meet the needs of the people of the state. This is done ırough the development of the program of work, this program being orked out in consultation with the county demonstration agents and ith committees representing the people of the county. The specialts work with the county demonstration agents, and give them assistıce in organizing and developing their work, and in seeing that the ork as carried out most nearly meets the needs of the various ıcalities.

The Extension Service and the Experiment Station

The closest and most cordial relationship exists between the memɔrs of the extension staff and the research staff of the Experiment tation. The extension workers must in a large measure depend upon ıe research work of the Experiment Station for the correctness of ıeir subject-matter extended. On the other hand, the members of ıe Experiment Station staff are kept informed of the problems which re arising throughout the state, and in this way we believe the service endered is mutual.

The county demonstration agents are called in for conference at ıe College about four times each year, and at these conferences they ıeet the members of the Experiment Station staff, discuss with them ıeir problems in the county, and are greatly benefited by the inɔrmation received.

The farmers of the state who are in need of assistance do not disnguish sharply between members of the extension, Experiment Staon, or College staff. What they desire is service, and with the close elationship which exists, we believe that this service is being rendered ı the largest measure possible.

The extension work along all lines as organized in the county is dapted to the apparent needs of the county. All lines are based upon program of work. In the development of this program of work ɔmmittees representing the people of the county, specialists repesenting the College, and the county demonstration agents take a art.

Agronomy and Farm Management

The investigational work in crops centered largely upon alfalfa and otatoes during the past year. This is the third year's work on strains f alfalfa seeded in different sections of the state. Seed coming from Kansas and the adjoining states still appears to be as good as o etter than that from other sources. It would appear that our results re now sufficiently extensive and have been gathered through a suffiiently long time to give us assurance in recommending Kansas seed or southern New Jersey. There is need for a more extensive trial ı the northern part of the state before definite recommendation ould be justified.

Tests of varieties of potatoes and sources of seed were conducted cooperation with the county boards of agriculture, and have shov much variation. They emphasize the necessity of more careful se selection by our growers.

A sub-station in the southern part of the state may prove to desirable for adequate work with farm crops. This is particular true for potatoes, corn, alfalfa and soy beans.

The cost-of-production studies during the past year have dealt wi both tomatoes and potatoes. The results of the work on tomatoes ha been highly important for our growers inasmuch as the industry ca not persist under present conditions unless New Jersey growers ca make a profit in their production and at the same time grow the cr at a price comparable with that obtained in other states. Cost-of-pr duction studies from other states have led to the belief that easte costs were too high, and that it might be necessary for the indust to change its location.

Through the efforts of the department, a conference was called representatives of the important tomato-producing states. It w attended by investigators, growers, canners and their representative This conference has led to the standardization of the methods th are to be used in the future for investigating and expressing the co of production of the tomato crop. It has, it is believed, created great confidence in the possibilities of profitable production of can-hou tomatoes in the Coast States.

The investigation of the cost of producing potatoes in the state h shown that, while the acre cost is high, the unit cost per bushel hundred-weight is not excessive. The future of this industry in Ne Jersey is full of promise.

Forty selected farms are carrying on detailed cost accounts in c operation with the department. This work will give fundamental ar much needed data on the cost of production of all agricultur products.

Soil Chemistry and Bacteriology

The work of this department for the past year has been carried on very much along the lines laid down in previous reports. Speci emphasis, however, has been laid on the sulfur-oxidation project, ar a new project on the limit of tolerance of corn and potatoes for bora has been started in cooperation with the Bureau of Plant Industr of the United States Department of Agriculture.

The field and cylinder projects on nitrogen availability and nitroge accumulation have been continued with little change. More attentio however, is being given to a study of the soil reaction and nitra formation in connection with certain of the plots.

The wheat that was seeded, in course of rotation, on a majority the field plots last fall was severely injured by the severe cold an heavy ice formation of the past winter and, on this account, it we

considered best to plow it under and reseed to barley. The latter has grown well and gives promise of a good crop, though with very pronounced differences, depending upon the fertilizer treatment. For the same reason it was necessary to spade under the rye on the nitrogen-accumulation cylinders and reseed these to barley.

In connection with the sulfur-oxidation experiment a large amount of laboratory work has been carried on, and field experiments are now under way to determine the effect of inoculated and uninoculated sulfur on rock phosphate and greensand marl. Work is also being carried on to determine the amount of sulfur which crops will tolerate. In connection with this work a study is being made with reference to the influence of the sulfur on nitrate formation in the soil. Pure cultures of sulfofying bacteria have been isolated. Some of the strains now under investigation have been found to be much more effective than any of the crude cultures in transforming sulfur into sulfuric acid. The environmental conditions affecting the activities of these organisms have been studied, and a mass of important data on this point made available. It was found, among other things, that the sulfofying bacteria derive their energy from the oxidation of sulfur and can, therefore, flourish in an inorganic medium. Mixtures have been made up of ground phosphate rock and inoculated sulfur and transformed gradually into acid phosphate. It is possible that this method of making acid phosphate may ultimately find wide application in the fertilizer industry. Experimental data at hand seem to indicate, also, that mixtures of inoculated sulfur and ground phosphate rock may prove suitable for direct use as a substitute for acid phosphate.

The cooperative fertilizer experiment with potatoes near Elmer, Salem County, has been continued as has also the triangle fertilizer experiment with corn, potatoes and alfalfa, which was started last year on the College Farm in cooperation with the United States Bureau of Plant Industry.

Approximately 100 samples of soil from the State Soil Survey work have been analyzed for total nitrogen, phosphoric acid, potash and carbon, and for lime requirement. The department has also taken care of a considerable number of miscellaneous samples for the extension department.

A 14 by 16-foot addition is being made to the Soil House, which will give additional room for the storage of samples and furnish a fertilizer storage and mixing room.

Plant Physiology

The department of plant physiology has experienced a marked increase in its activities during this year. The principal lines of research followed during the previous year have been continued with some modification. With the addition of several new members to the

staff of workers new lines of research were undertaken with a consequent expansion of the scope of the laboratory activities.

Attention has been given during the year to the following lines of research.

The Salt Requirements of Representative Agricultural Plants

This work has been continued as previously outlined with wheat in solution cultures and with potatoes in sand cultures, and successful progress has been made.

The Influence of Washed and Unwashed Sand of Different Degrees of Fineness Upon the Reaction and Upon the Effective Concentrations of a Nutrient Solution for Plants

This work has been completed during the year and the results have been published.

The Relation of Moisture in Solid Substrata to Physiological Salt Balance for Plants and to the Plant-Producing Value of Various Sal Proportions

The investigations which were begun with sand cultures in which nutrient mixtures in solution form were diffused as films over the sand particles were completed during the year and the results of the work have been published. This work is now being continued with soil cultures and considerable progress has been made.

The Relation of Hydrogen-ion Concentrations to Plant Growth and the *Influence of Plant Growth Upon the Reaction of the* Media in Which Plants are Grown

A portion of this work has been completed and the results thus far obtained are ready for publication. Considerable time and energy has been given to the development of method and apparatus for the convenient and accurate determination of the hydrogen-ion concentrations of nutrient solutions for plants, water extracts of soils or soil suspensions, etc., by the colorimetric method. A convenient apparatus has been developed by means of which the hydrogen-ion concentrations of clear or somewhat turbid solutions can be determined rapidly and accurately.

The Study of Ammonium Sulfate in Relation to Plant Growth

A study is being made of the effect ammonium sulfate has upon the plant growth when used as a constituent in a complete fertilizer,

nutrients in media for plant growth. It has already been determined that ammonium sulfate, when added to a nutrient solution for plants, will make available to the plants food which was not previously available. This work is being conducted with water cultures and soil cultures in the greenhouse. Field tests also are being carried out.

The Relation, Availability and Efficiency of Various Soluble and Insoluble Iron Compounds in Relation to Plant Production

Investigations of the conditions under which plants can best obtain the iron necessary for growth, and the condition of form of iron which is best for absorption by the roots of different species of plants under given sets of experimental conditions, has received little attention. The employment of the usual "trace" of iron in culture media without regard to its constitution or to the nature of the media in which it is employed has proved entirely inadequate for some species of plants. During the year research was undertaken in an endeavor to obtain some definite information with respect to the use of iron as one of the essential constituents of nutrient media for culture studies with green plants. Progress has been made with several phases of the iron problem.

The Influence of Green Plants Upon the Oxidizing Flora of the Soil

Using as an index the evolution of carbon dioxide from the soil, it has been determined that growing green plants exert considerable beneficial influence upon the activities of the micro-organisms which are concerned with the oxidation of the organic matter in the soil. The experiments thus far carried out appear to demonstrate a symbiotic relationship between growing green plants and the oxidizing flora of the soil.

Entomology

During the year which came to an end on June 30, 1920, there have been no important changes in the personnel of the department.

Investigations of the pear psylla have definitely shown that this insect is capable, when abundant for a period of years, of eliminating practically all the profit in pear growing. They have also served to develop an apparently satisfactory method of bringing this insect under control. This method of control involves:

1. Spraying the orchard completely with soluble oil between the dropping of the leaves in the fall and the opening of the buds in the spring at such times as the pear psylla adults are found clinging to the twigs and smaller branches so stiff with cold as to be unable to move.
2. Completely coating the orchard with winter-strength lime-sulfur just before the blossom buds open into flowers.

3. Thoroughly coating the under-side of the foliage with commercial lime-sulfur 1 to 40 or self-boiled lime-sulfur whenever during the growing season droplets of honey-dew appear in considerable numbers on the under-sides of the leaves. The control effected by this series of treatments serves not only to preserve the fruit from staining, but to hold the foliage on the trees much later in the season and to permit the development of good healthy fruit buds for the next year's crop.

Investigations of the codling moth have shown that this insect is apparently two-brooded, that present methods of controlling the blossom-end injury are efficient, that present methods of controlling the injury by side-worms of the first and second broods are inefficient and that a complete coating of the poisonous material maintained on the apple fruit and foliage during the periods when the side-worms of the first and the side-worms of the second broods are entering, gives efficient and satisfactory protection of fruit. These investigations show definitely that three sprays are necessary for the control of this insect. The first must be made within a week after the falling of the petals and the second must be made when the side-worms of the first brood begin to enter the fruit. The coating thus given must be maintained until the period of entering has come to an end. The third must be applied when the side-worms of the second brood of the codling moth have begun to enter and the coating obtained must be maintained until the period of entering comes to an end.

Depending upon the weather, the second treatment may consist of a single or of more than one spraying and the same condition obtains with regard to the third treatment.

Investigations of insecticidal dusts during the past year have shown:

1. That dust mixtures consisting of finely divided sulfur and powdered arsenate of lead are only one-half as effective in the control of curculio and codling moth on apple as are lime-sulfur and arsenate of lead spraying mixtures.

2. That a far more complete coating of the apple fruit and foliage can be obtained with dust-applied materials than with liquid sprays.

3. That the reason underlying the relative inefficiency of the dust-applied materials is the inability of these mixtures to stick to the fruit and foliage of the apple.

4. That if a sticker could be found and introduced into sulfur-arsenical dusts causing them to cling to the fruit and foliage with the same tenacity as similar materials applied wet, their insecticidal value would be approximately equal.

Investigations of the peach borer show that the Scott tree protector reduces but does not entirely eliminate infestation of the peach. They also show that, while all protectors give a considerable degree of reduction of infestation, none serves as a complete preventive.

Investigations of the strawberry root worm, or rose typophorus, have already shown this insect to be a most serious interference with rose production under greenhouse conditions. It breeds in the soil of the benches on which the roses are grown and produces two broods a year. It may be greatly reduced by hydrocyanic acid gas fumiga-

tion without serious damage to the rose plants if it is made during the latter part of the drought period late in June or early in July. It may be efficiently repelled by coating the plants with hydrated lime, or it may be brought under excellent control by means of a hand-collection method. This last method is the one used successfully at the greenhouse plant of H. O. May, at Summit, N. J. By its employment Mr. May has reduced this insect to a point where its damage to the roses is almost, if not quite, negligible. Men are sent along the benches carrying tin pans. At each plant a man stops and holds the pan below the plant and beats the wire support causing the beetles to fall into the pan where they are killed by kerosene.

Cranberry plant-food investigations for the year just passed show:

1. That 30 pounds of nitrogen to the acre of Savannah bottom is better than 20. Previous investigations have shown that 40 pounds is too much.
2. The practice of drawing nitrogen from a combined mineral and organic source does not give a better crop than when the same is taken from nitrate of soda alone.
3. The optimum amount of phosphoric acid is at least 80 pounds per acre on Savannah, mud and iron-ore bottoms.
4. The optimum amount of tentative mixed fertilizers formula is about 800 pounds per acre, with which about 500 pounds of acid phosphate could be applied the first years.
5. Calcium cyanamide is an unsatisfactory source of nitrogen.
6. Barium phosphate is an unsatisfactory source of phosphoric acid.

Cranberry investigations in soil acidity have not resulted in data from which it is possible to draw practical conclusions. The lime treatments appear not to have proven particularly effective one way or the other during the year just passed.

Cranberry investigations of the blossom worm have shown that this insect has tremendously increased and that wherever the reflow for the black-head fire-worm has been left in the bog for 24 hours, all areas completely covered by water for that period are freed from injury by this insect for the current year. Investigation of the cranberry girdler has shown that it can be killed locally by an application of 1 ounce of sodium cyanide dissolved in 25 gallons of water and applied at the rate of 1 gallon to the square foot. Attempts to use this method in the field have resulted in failure by reason of the fact that, the coating of the leaves and rubbish on the bog floor rendered it impractical to get the material into the soil. The problem to be solved seems to be one of introducing a material in such a way as to insure the penetration of this coating of leaves and rubbish on the bog floor.

Sewage investigations of the year just passed have shown:

1. That there are present in the film of the sewage filter organisms which are similar to those occurring in the soil acting to oxidize nitrogen from ammonia to nitrite and from nitrite to the nitrate form, and that this process is a gradual change starting in at the top layer of the filter with the zone of greatest activity lying in the central layer.

2. That a rapid decrease of bacterial content of the sewage occurs as it passes over the stones of the filter and at the same time there is a proportional increase in the bacterial content of the film. This seems to bear out the statement that the theory of absorption as advanced by Dunbar would apply to microscopic organisms as well as to complex chemical compounds.

3. That there are enzymes present in the film which act to break up proteins into their more simple amino compounds and these amino compounds eventually into ammonia.

4. That there are present enzymes acting to break down maltose, dextrose and sucrose. No lactose-splitting enzymes were found to be present, and the active urase was demonstrated as acting to split urea into ammonia and carbon dioxide.

The work on mosquito control during the past year has included:

1. Continuance of mosquito control within and in the vicinity of the New York Shipbuilding Corporation plant, New Jersey and Pennsylvania Shipbuilding plant and the Camden Forge.

2. Preparation of plans and specifications for mosquito drainage of Dismal Swamp in Middlesex County.

3. Preparation of plans and specification for the outlet of Fishing Creek salt marsh, Cape May County.

4. The cutting of 60,000 linear feet of ditches 10 inches wide and 15 inches deep and of 14,074 feet of ditches 10 inches wide and 30 inches deep, or their equivalent, on the salt marshes at Island Beach, below Seaside Park, Berkley Township, Ocean County.

5. The cutting of 40,000 linear feet of ditches 10 inches wide and 15 inches deep, or their equivalent, and 26,000 linear feet 10 inches wide and 30 inches deep, or their equivalent, at Island Beach, Berkley and Lacey townships, Ocean County.

6. The cutting of 68,250 linear feet of ditches 10 inches wide and 30 inches deep, or their equivalent, in Upper Township and of 68,250 linear feet of ditches 10 inches wide and 30 inches deep, or their equivalent, in Middle Township, Cape May County.

7. General oversight of the county mosquito-control work in Hudson, Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Ocean, Atlantic, Cape May and Morris counties.

All told, 1,376,191 linear feet of new ditching has been cut in the salt marshes during the year just passed. Of this amount 230,074 feet was cut by the Station and 69,700 feet was cut by private corporations under county mosquito commission directions. About 5,000 acres of marsh not hitherto drained has been relieved by these operations and large acreages of incompletely drained territory have been improved.

The work of mosquito control, in addition to permanent salt-marsh improvement above outlined, has included the patrol throughout the mosquito-breeding season of about 320,000 acres of upland and 115,000 acres of salt marsh; the distribution of 1,400 barrels of oil, and the drainage of a very large acreage of upland swamp. This work has covered a territory in which about 2,000,000 New Jersey people live and has rendered a high degree of protection throughout a large part of the area.

Plant Pathology

The most important work of the department during the past year has been concerned with the following problems: the influence of Bordeaux and other spray mixtures on potatoes; the influence of mosaic and leaf roll on the yield of potatoes; the transmission of *Sclerotinia Cinerea* (brown rot of peach) from year to year; the causes of tomato fruit rots; the removal of fruit-tree cankers; the relation of sulfur to soil acidity and the control of potato scab; physiological studies of *Actinomyces scabies;* studies of physiological diseases of potatoes; the relation of soil reaction to the growth of pathogenes; fungi injurious to paints; spraying of pears for the control of leaf and fruit spot; spraying cherries for the control of leaf spot; studies on eggplant wilt; root rot of celery; root rot of horse-radish; control of diseases of sweet potatoes, control of diseases of tomatoes, and parasitology of *Cuscuta gronovii.*

About two hundred diseases of economic crops were given consideration during the year. An unusually large number were especially severe and were the cause of heavy losses. Among the most important are brown rot of peach, late blight of potato, potato scab, root rot of pea, leaf and fruit spot of pear, stem canker on tomatoes, cabbage and peppers, leaf blight of tomato, cabbage black leg, cherry leaf spot, root rot of celery, root rot of corn, root rot of horse-radish, leaf fall of pepper.

The department has worked in cooperation with the State Department of Agriculture in the inspection of nurseries and other duties. The potato wart has not been found in the state and there have been no recent outbreaks of the white pine blister rust.

There is need for a well trained extension plant pathologist who could relieve the department of some of the correspondence and conduct demonstrations for the control of plant diseases. This work cannot be entrusted to horticulturists who are not trained in plant pathology without considerable unnecessary waste. The use of untrained men may lead to failure. The department needs a man to conduct work on strains resistant to diseases, work which is already under way in other states and is giving good results. There is need also for the men and funds to be used in work on soil organisms which cause diseases, wilt diseases, mosaic and yellows, grain and forage crop diseases and storage diseases.

Library

The library in the Agricultural Building contains approximately 5,400 bound volumes and a great amount of unbound material. This material consist of publications from the United States Department of Agriculture, the State Experiment Stations, the most scientific and

rm journals and the livestock record books from the various record associations, and a large number of authored books on the many branches of agriculture. An effort is being made continually to build up the library and to make it adequate for the work of the Experiment Station.

During the fiscal year 100 volumes of publications were bound, and 2,700 publications, bound and unbound, were loaned. The library is very much in need of more space for stacks, filing cabinets and reading tables. At present these stacks and shelves are over-crowded and very often there are more students using the tables than can be properly accommodated. For the use of the library adjoining rooms should be added to the one room the library now occupies, and funds should be provided for additional furniture and equipment, and also for the purchase of books.

Oyster Research

The absence of the assistant biologist, Dr. Thurlow C. Nelson, on account of war service had led to the temporary discontinuance of some of the oyster research activities. On the return of Dr. Nelson from the service, arrangements were made to prosecute actively the investigations that had been continued for a number of years and to attack them from a new angle. It is gratifying to report that within the year just passed a very substantial addition has been made to our knowledge of oyster propagation—thanks to the investigations at our oyster laboratory and elsewhere.

Most of the work was done at Edge Cove and other portions of Little Egg Harbor. This consisted of the study of organisms used as food by oysters. A brief survey was made of the upper waters of Barnegat Bay from Cedar Creek northward to Barnegat pier. Certain interesting facts were developed between the relation of the density of the water and the feeding of the young oysters. Since March, 1919, considerable emphasis has been laid on four points in connection with oyster investigations, viz.: (1) studies on the rate of growth with adult oysters, (2) analyses of stomach content of adult oysters to determine types of food eaten, (3) observation of the feeding habits of oysters as affected by environmental factors, and (4) further studies of the duration of the larval period and the conditions governing the setting period.

Certain interesting facts have been brought out, as, for instance, that, under suitable environmental conditions, oysters may feed for about 20 hours out of 24 each day and that there is a definite relation between the commencement of feeding and the stage of the tide. There is apparently, also, some relation between the period of feeding and the time of the day. It was shown that below a density of 1,010, oysters do not as a rule open to feed. Contrary to the belief expressed by other investigators, a moderate increase in turbidity of the water does not cause a cessation of feeding

Publications

The work of the department of publications has progressed along he lines outlined when the work was reorganized over a year ago. The department has found the Committee on Publicity to be of nvaluable assistance in developing the work. Plans for extending he work and various problems that have arisen, have been taken up y the committee and presented to the Experiment Station Council or their approval before being acted upon. Such procedure has nsured progress along sound lines and has guaranteed the support f the institution as a whole for the work of the department.

Regular Publications

The regular series of publications established in previous years vere continued this year and are listed below. Little change was nade in these publications except in the way of an effort to improve heir appearance through the use of paper of good quality, better tyles of type and the more general use of illustrations.

A special effort was made to economize in the distribution of our egular publication in order to conserve our present funds. The lassification of the mailing list proved to be a big factor in this espect and made it possible for us to reduce the edition of some of he publications very materially, and to distribute them more effi-iently.

"New Jersey Agriculture"

The monthly publication, New Jersey Agriculture, has proven to e one of the best lines of publicity which the department has at-empted. It has been so successful that beginning July 1 the mailing ist will be increased to over 10,000 addresses, including all names n our general mailing list. It is also intended to increase the size f the issue every second or third month from 8 to 16 pages, devoting he additional eight pages to the investigational work of the Experi-nent Station.

Extension News Service

The publicity work of the Experiment Station, the College of Ag-iculture and the Division of Extension, has been combined in the ne department of publications, thus insuring the closest cooperation n publicity work among the different divisions and avoiding duplica-ion of effort. The news service to the press of the state has been omewhat modified. The Weekly News Letter was discontinued on

July 1, 1919, and replaced by the Special News Service. It has been the policy during the past year to reduce the amount of material furnished the press of the state, limiting it to material of a more essential nature, prepared in a more usable form. Stories have been sent out in mimeographed form and among this material may be mentioned certain series that have been maintained and have been used very generally by the newspapers, namely, Timely Tips to Gardeners, Rural Ruminations, and Home Cogitations.

Special Publicity Service

A special publicity service in addition to the regular Extension News Service was carried out through feature stories for Sunday papers and foreign periodicals, local stories to county papers, dailies, etc. The annual meeting of the State Horticultural Society at Atlantic City, and the annual convention of the State Mosquito Extermination Association were covered by representatives of the department, and through cooperation with the Atlantic City papers and the city Chamber of Commerce, very good publicity was obtained for these meetings.

Special Publications

Some special material was published during the year, such as folders advertising the courses in agriculture and boys' and girls' club work, announcements of the Summer Field Meeting, etc. Special publicity work was done in connection with the Summer Field Meeting and other events held at the College.

The County Farm Demonstration News

The county agents have been assisted in the publication of their county monthly papers through the editing of the copy and the checking of all subject-matter at the College. The county agents also have been assisted through constructive suggestions by the department, concerning their publicity work. A marked improvement in the quality of the County Farm Demonstration News is noticeable within the past two years.

Technical Series of Papers

The members of the staff for years past have contributed a large number of scientific papers to technical journals. This material when assembled would make a large and valuable addition to the scientific

terature of the country. Because the material has been scattered, owever, much has been lost and it is now practically impossible to ake a complete collection of it. In view of this need, it was decided establish a technical series of scientific papers, so that all papers epared by members of the staff and published in scientific journals e given a series number. The Experiment Station purchases reints and copies are filed to be bound for permanent keeping in the brary. Special forms for handling this material have been preared. In this connection it may be mentioned that the department as issued a style sheet to members of the staff for their use in preiring various Station and College publications.

"Soil Science"

Soil Science, which was established at Rutgers College in 1916, still edited at the New Jersey Station, the director being editor-inief. The Williams and Wilkins Company, of Baltimore, Maryland, ntinue as publishers. This journal has become established as one the important international agricultural scientific journals and has large foreign circulation. It has furnished an excellent medium for e publication of the results of researches in soils, plant physiology d other lines of work at the Station and has meant a very material ving in funds for printing technical bulletins.

Exhibits

The institution has done some work in the way of exhibits during e past year in which the department of publications has cooperated. has not been able to undertake exhibits on a large scale on account a shortage of funds. A small exhibit of the work of the institution as staged at the Inter-State Fair in the fall of 1919, being directly charge of Howard F. Huber, assistant state leader of farm demonration at that time. An exhibit of station publications, charts and emonstration material was shown at the Annual Meeting of the State orticultural Society, at Chalfonte Hotel, at Atlantic City, in Deember. Also, a small exhibit was staged in the armory at Trenton ıring the Agricultural Week. Special exhibits of the publications the College and Experiment Station and a set of standard agriıltural books under the title "The Farmer's Bookshelf," attracted onsiderable attention at the Summer Field Meeting at New Brunsick. Books for the "Farmer's Bookshelf" were donated by the rious publishers, whose courtesies are hereby gratefully acknowlged.

A special exhibit of the work of the department of publications was epared for the Annual Conference of the American Association of gricultural College Editors, held in June, at Amherst, Massachu-

setts. In the competition among exhibits from the various agricultural colleges in the United States, the New Jersey exhibit was awarded second place for general display and third place for effectiveness of agricultural information conveyed through print.

Personal Work With Newspapers

The editor has undertaken a survey of the newspapers of the state and during the past year has visited approximately 200 newspaper offices. The survey is still under way, and it is expected that it will be completed within the next few weeks. Where feasible, the newspapers have been visited in company with the county agent of the county in which the papers are located, and effort has been made to show the relationship between the county agent and the Agricultural College. The general purpose of these visits is to establish personal relations with the publishers of the newspapers, to get the newspaper-man's point of view, to learn his desires with respect to our news service, and to obtain any suggestions as to the improvement of our service that he may have to offer, all of which should tend toward a more efficient service to the newspapers and closer cooperation between the university and the press. The editor is a member of the New Jersey State Press Association, and attended their winter meeting at Trenton in February.

Work With High Schools

In cooperation with the Committee on Secondary Schools of the Rutgers College Alumni Council, the editor visited 35 high schools in the state, during the months of March, April and May, addressing the students on the value of a college training. While the university as a whole was represented in these talks, emphasis was placed on the opportunities for agriculture in New Jersey and the work of the Agricultural College and Experiment Station in training young men and women for leadership in this industry. Special publicity with the newspapers was conducted in connection with this high-school work. In general, the school officials cooperated cordially in these visits, and it is believed that this sort of work is effective and well worth while. It is recommended that during next season a more extensive and carefully arranged program of high-school work be undertaken.

The Mailing Service

During the year there has been a marked improvement in our mailing service made possible by the employment of a full-time mailing clerk. The mailing list has been increased and further revised, so that at present we have over 9,000 New Jersey addresses on

our mailing list and 3,500 addresses outside of the state. A revision has been made of the foreign mailing list which was temporarily discontinued during the war. A large number of requests have come *from* foreign countries and these have been filled either directly or through the Smithsonian Institution at Washington, D. C. In addition to the regular publications as issued, a large number of requests for available bulletins and circulars have been received from individuals, libraries, etc. In an effort to get a better idea of the magnitude of our bulletin service, an accurate record was kept of the number of publications sent out for a period of about seven weeks. From December 11, 1919, to January 31, 1920, over 14,000 publications were mailed in response to special requests, or a daily average of over 300 publications. Using these figures as a basis of an estimate, the following summary of our circulation for the past year was prepared.

Requests. Dec. 11, 1919, to Jan. 31, 1920:		
Number of requests 1,545—(daily average 36)		
Number of publications 14,042—(daily average 326)		
Estimated total per year:		
Number of requests	10,000	
Publications distributed	100,000	
Departmental requests estimated:		
Number of requests	5,000	
Publications distributed	25,000	
Total requests		15,000
Total publications		125,000
Addresses on regular mailing list:		
In New Jersey	9,000	
Out of State	3,500	
New Jersey Agriculture	3,500	
Publications sent to mailing lists as issued:		
Estimated 1919-1920	185,000	
New Jersey Agriculture	40,000	
Total	225,000	
Total circulation:		
To mailing lists	225,000	
By request	125,000	
Total	350,000	

Cooperation

The department has cooperated with various agencies other than those mentioned above in its publicity work. Mention should be made of cooperation with the State Department of Conservation and Development in the publication of their most excellent booklet, "New Jersey for Progressive Farmers." Also, the department has cooperated with the State Potato Association in the publication of their monthly circular, "Hints to Potato Growers." In the distribution

of publications, the department has found cooperation with the St Department of Agriculture of mutual benefit. The State Chaml of Commerce rendered valuable aid by donating space in "N Jersey," the Legislative Index, for articles concerning certain pha of our work.

The librarian of the United States Department of Agriculture h very kindly furnished bibliographical information on a number occasions which has been of great assistance in our editorial work.

Also, requests for cooperation in the use of publications or in pu licity work that have come from other state or county organizatio have been readily met so far as facilities were available.

Organization of the Work

With the growth of the work of the department it has been nece sary to create a more highly specialized organization. This has be accomplished by the assignment of specific duties to the differe members of the staff. In this connection, the need for placing t work on a definite basis and outlining a program of the year h become apparent. Beginning with the next fiscal year, programs publicity will be drawn up with the separate departments and the incorporated in a single program for the department. Also, tl different activities will be classified under definite projects. It thus expected to do better work than has been possible in the past.

Needs of the Department

The department needs additional equipment and room. There inadequate space for the storing of publications, and filing cabine are needed for electroplates and other material. The purchase of multigraph machine would mean a considerable saving in the matt of small printing, and it is hoped that funds may soon be availab for this machine. A folding machine also is needed for the Speci News Service and other material.

As the institution grows, it should look forward to the establisl ment of a printing and publishing plant of its own, such as ma be found at a number of agricultural colleges and experiment statio in the country. This would make possible more prompt publicatio a greater uniformity among our publications, and in general a mo efficient service. The work has not developed to the point that woul warrant such an effort at this time, but with normal growth, the ac visability of the Station having its own publishing plant within a fe years should be considered.

Publications

Bulletins

No.
337 Analyses of Commercial Fertilizers, Fertilizer Supplies and Home Mixtures.
338 The First Two Years of the Vineland Contest.
339 Analyses of Materials Sold as Insecticides and Fungicides During 1919.
340 Analyses of Commercial Fertilizers and Ground Bone; Analyses of Agricultural Lime.
341 Fertilizer Registrations for 1920.
342 Analyses of Commercial Feeding-Stuffs and Registrations for 1920.
324 The Strawberry Weevil. (Reprint.)
328 Some Important Orchard Plant Lice. (Reprint.)
329 Profits and Factors Influencing Profits on 150 Poultry Farms in New Jersey. (Reprint.)

Circulars

No.
110 State Laws Concerning Mosquito-Control Work in New Jersey.
111 The Mosquito Must Go.
112 Common Diseases of Celery.
113 Common Thistles.
114 Sweet Potato Culture and Storage in New Jersey.
115 Standard Poultry Houses. (Revision of Bul. 325.)
116 Spray Calendar for Apples and Quinces.
117 Spray Calendar for Peaches.
118 Spray Calendar for Pears.
119 Spray Calendar for Plums.
120 Spray Calendar for Cherries.
48 Bordeaux Mixture. (Reprint.)
80 Common Diseases of Apples, Pears and Quinces. (Reprint.)
81 Common Diseases of the Peach, Plum and Cherry. (Reprint.)
91 The Bean Weevils. (Reprint.)
117 Spray Calendar for Peaches. (Reprint.)

Reports

1919 Fortieth Annual Report of the New Jersey State Agricultural Experiment Station, and Thirty-second Annual Report of the New Jersey Agricultural College Experiment Station.

Hints to Poultrymen

Vol. 7, No. 10, July, 1919.
Artificial Illumination of Poultry Houses to Increase Fall and Winter Egg Production, VICTOR G. AUBRY.
Vol. 7, No. 11, August, 1919.
The Chicken Pox, Roup and Canker Problem in New Jersey, WILLARD C. THOMPSON.
Vol. 7, No. 12, September, 1919.
Fall Poultry Problems, HARRY R. LEWIS.
Vol. 8, No. 1, October, 1919.
Hens vs. Pullets, RALSTON R. HANNAS.
Vol. 8, No. 2, November, 1919.
Judging Fowls for Egg Production, HARRY R. LEWIS.
Vol. 8, No. 3, December, 1919.
Report of the Third (Pullet) Year of the Vineland 1 Laying and Breeding Contest, RALSTON R. HANNA

Vol. 8, No. 4, January, 1920.
The Cost of Producing Eggs on a One-Man Poultry Farm in New Jer for 1919, VICTOR G. AUBRY.

Vol. 8, No. 5, February, 1920.
Poultry Rations and Methods of Feeding, HARRY R. LEWIS.

Vol. 8, No. 6, March, 1920.
"Safety First" in the Poultry Yard, WILLARD C. THOMPSON.

Vol. 8, No. 7, April, 1920.
Standard Scores of the Birds at the Second Vineland International E Laying and Breeding Contest, RALSTON R. HANNAS.

Vol. 8, No. 8, May, 1920.
Summer-Time and the Pullets, WILLARD C. THOMPSON.

Vol. 8, No. 9, June, 1920.
The Bergen County International Egg-Laying and Breeding Conte HARRY R. LEWIS.

(Reprints) Vol. 2, No. 5.
Vol. 5, Nos. 5-8, 12.
Vol. 6, Nos. 5-6, 8, 11-12.
Vol. 7, Nos. 2-7, 10-11.
Vol. 4, No. 6.
Vol. 8, Nos. 1-3.

Extension Bulletins

Vol. 1, No. 24. Club Work. The Child and the Rural Community.
No. 25. Dairy Judging for Juniors—Boys' and Girls' Club Work.

Extension Circulars

No.
7 Canning Record.
8 Lime—The Key to Soil Fertility.
9 Weed Out Your Unprofitable Cows.
10 Intelligent Feeding is Essential to Successful Dairying.
11 Improve Your Herd by Intelligent Breeding.
12 Home Mixing of Fertilizers.
13 Home Selection and Saving of Tomato Seeds.

New Jersey Agriculture

Vol. 1, Nos. 7-12.
Vol. 2, Nos. 1-6.

Papers by members of the staff, which have appeared in various publication are given below.

Technical Papers

The following technical papers have been published by the members of th staff during the year:

The Relative Availability of Nitrate Nitrogen and Organic Nitrogen—Fiel and Cylinder Experiments. A. W. Blair. *Journal of Industrial and En gineering Chemistry*, vol. 12, no. 3, March. 1920.

The Lime Requirement of Soils According to the Veitch Method Compare With the Hydrogen-ion Concentration of the Soil Extract. A. W. Blai

The Protozoan Fauna of the Soils of New Jersey. C. R. Fellers and F. E. Allison. *Soil Science*, vol. 9. no. 1, January, 1920.

Hydrogen-ion Concentration Measurements of Soils in Connection With Their "Lime Requirements." Jacob S. Joffe. *Soil Science*, vol. 9, no. 4, April, 1920.

The Lime Factor in Permanent Soil Improvement. A. W. Blair and J. G. Lipman. I. Rotations without Legumes. II. Rotations with Legumes. *Soil Science*, vol. 9, no. 2, February, 1920.

Field Experiments on the Availability of Nitrogenous Fertilizers, 1908-1917. J. G. Lipman and A. W. Blair. *Soil Science*, vol. 9, no. 5, May, 1920.

The Potential Biochemical Activity of the Spores of Soil Bacteria. J. R. Neller. *Soil Science*, vol. 9, no. 5, May, 1920.

Influence of Sodium Chloride Upon the Physiological Changes of Living Trees. W. Rudolfs. *Soil Science*, vol. 8, no. 5, November, 1919.

Experiments on the Value of Common Rock Salt and Sulfur for Killing Live Stumps. W. Rudolfs. *Soil Science*, vol. 9, no. 3, March, 1920.

Cultural Studies of Species of Actinomyces. S. A. Waksman. *Soil Science*, vol. 8, no. 2, August, 1919.

Studies in the Metabolism of Actinomyces II. S. A. Waksman. *Journal of Bacteriology*, vol. 4, no. 14, July, 1919.

Studies in the Metabolism of Actinomyces III, Nitrogen Metabolism. S. A. Waksman. *Journal of Bacteriology*, vol. 5, no. 1, January, 1920.

Studies in the Metabolism of Actinomyces IV. Chances in Reaction as a Result of the Growth of Actinomyces Upon Culture Media. S. A. Waksman and Jacob S. Joffe. *Journal of Bacteriology*, vol. 5, no. 1, January, 1920.

Review of "Plant Products and Chemical Fertilizers." S. Hoare Collins and Jacob G. Lipman. *Journal of the American Chemical Society*, vol. 42, no. 6, June, 1920.

Chapters on Soils, Third Edition Marshall's "Microbiology." Jacob G. Lipman.

Taxing the Air for Increased Food Production. Jacob G. Lipman. *Journal of the American Society of Agronomy*, vol. 2, no. 9, December, 1919.

The American Association for the Advancement of Science. Section O—Agriculture. Jacob G. Lipman. *Science*, vol. 52, no. 1333, July 16, 1920.

Some of the New Applications of Sulfur in Agriculture. Jacob G. Lipman. *Chemical Age*, vol. 28, no. 7. July, 1920.

Modern Development in Peach Growing. M. A. Blake. *Massachusetts Department of Agriculture*, Circular 22.

Economic Temper of the Farmer. Frank App. *Journal of Farm Economics*.

Some Insect Problems of the Potato Grower. T. J. Headlee. *New Jersey State Department of Agriculture*, Bul. 24, March, 1920.

Control of the Principal Insects Injurious to Apple and Pear Above Ground. T. J. Headlee. *Proceedings of the Connecticut Pomological Society*, April 19, 1920.

Progress in Control of Principal Insects Injurious to Apple and Pear Trees Above Ground. T. J. Headlee. *Proceedings of the Peninsula Horticultural Society* for 1919-1920.

Some Experience With the Codling Moth. T. J. Headlee. *Journal of Economic Entomology*, vol. 13, no. 2, 1920.

The Relation of Sulfur to Soil Acidity in the Control of Potato Scab. W. H. Martin. *Soil Science*, vol. 9, no. 6, June, 1920.

Response of the Eggs of *Aphis avenae* Fab. and *Aphis pomi* DeG. to Various Sprays, Particularly Concentrated Lime-Sulfur and Substitutes; Season of 1918-1919. Alvah Peterson. *Journal of Economic Entomology*, 1919, vol. 12, no. 5.

A Preliminary Report on the Use of Sodium Cyanide for the Control of the Peach Tree Borer (*Sanninoidea exitiosa* Say). Alvah Peterson. *Journal of Economic Entomology*, vol. 13, no. 2, 1920.

The Effect of Certain Nitrogenous and Phosphatic Fertilizers on the Yield of Cranberries. C. S. Beckwith. *Soil Science*, vol. 8, no. 6, December, 1919.

Relation of Moisture in Solid Substrata to Physiological Salt Balance for Plants and to the Relative Plant-Producing Value of Various Salt Proportions. *Journal of Agricultural Research*, vol. 18, pp. 357-378, 1920.

The Influence of Sand Upon the Concentration and Reaction of a Nutrient Solution for Plants. John W. Shive. *Soil Science*, vol 9, no. 3, March, 1920.

Popular Papers

Seed Corn Situation. Frank App. *American Agriculturist*. Nov. 22, 1919.

Late-Crop Seed Potatoes. Frank App. *American Agriculturist*. Dec., 1919.

Seed Potatoes for 1919. Frank App. *American Agriculturist*. Dec., 1919.

Points in Harvesting Small Grains. Frank App. *New Jersey Agriculture*. July, 1919.

Race for the Frelinghuysen Cup Will be Hot and Heavy. Frank App. *New Jersey Agriculture*. November. 1919.

The Greatest State Corn Show in New Jersey. Frank App. *New Jersey Agriculture*, December. 1919.

Best Corn Show in the East. Frank App. *New Jersey Agriculture*, February 1920.

Home-Grown Alfalfa Seed is Scarce This Year. Frank App. *New Jersey Agriculture*, February. 1920.

Cost of Production. Frank App. *New Jersey Agriculture*, April, 1920.

Preparing for 1920 Garden. A. W. Blair. *Newark Sunday Call*, March 7, 1920.

Relative Value of Nitrogen Material. A. W. Blair. *Pennsylvania Farmer*, March 13, 1920.

Fillers of Makeweights in Fertilizers. A. W. Blair. *Pennsylvania Farmer*, May 1, 1920.

Plant Life Fails Without Nitrogen. A. W. Blair. *Philadelphia Public Ledger*, March 21, 1920.

The Relative Availability of Nitrate Nitrogen and Commercial Organic Nitrogen in Cylinder and Field Experiments. A. W. Blair. *American Fertilizer*, vol. 51, no. 6. 1919.

Making the Farm Home Attractive. M. A. Blake. *Annual Proceedings of the New Jersey State Horticultural Society*, 1920.

Packing the Market Egg. R. R. Hannas. *Country Gentleman*, July 19, 1919.

Hens vs. Pullets. R. R. Hannas. *Country Gentleman*. October 25, 1919.

Precautions with the Incubator. R. R. Hannas. *Pennsylvania Farmer*, March 6, 1920.

The Best Sized Flock. R. R. Hannas. *Country Gentleman*, March 20, 1920.

Chicks That Count—Part I. R. R. Hannas. *Rural New Yorker*. April 17. 1920.

Chicks That Count—Part II. R. R. Hannas. *Rural New Yorker*. April 24. 1920.

Methods of Filling the Gaps of the Weak Hatch. R. R. Hannas. *Pennsylvania Farmer*, June 5, 1920.

Power-Harvesting Jersey Potatoes. Carl R. Woodward. *Country Gentleman*, February 7. 1920.

Cellar-Window Cold Frame. Carl R. Woodward. *Country Gentleman*, April 24. 1920.

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An Agricultural Program for New Jersey. Jacob G. Lipman. *New Jersey State Department of Agriculture*, Bulletin 23, February, 1920.

Lessons Learned from Seed Inspection Last Season. M. T. Cook. *New Jersey State Department of Agriculture*, Bulletin 24, March, 1920.

Potato Scab Control. W. H. Martin. *New Jersey State Department of Agriculture*, Bulletin 24, March, 1920.

The Cost of Producing Potatoes in New Jersey. Frank App. *New Jersey State Department of Agriculture*, Bulletin 24, March, 1920.

Results of Fertilizer Experiments. J. G. Lipman. *New Jersey State Department of Agriculture*, Bulletin 24, March, 1920.

Breeding Experiments With Dairy Cattle. W. M. Regan. *New Jersey State Department of Agriculture*, Bulletin 24, March, 1920.

Report of the Secretary-Treasurer of the New Jersey Alfalfa Association. Frank App. *New Jersey State Department of Agriculture*, Bulletin 24, March, 1920.

Comments on the Corn Show. Frank App. *New Jersey State Department of Agriculture*, Bulletin 24, March, 1920.

Staff Changes

The following changes have been made in the staff during the past year:

July	15.	Arthur L. Prince, Assistant Soil Chemist,
August	1.	Lindley G. Cook, Assistant to the Director.
September	1.	Elmer L. Sargent, Research Assistant,
		Robert P. Armstrong, Associate Pomologist,
October	1.	Clarence Gordon, Mailing Clerk,
November	1.	Olive Clinton, Stenographer,
		Lester R. Smith, Assistant Chemist,
December	1.	Carolyn N. Netzel, Statistician,
January	1.	Clarence H. Steelman, Orchard Foreman
	15.	Noyes S. Purrington, Fertilizer and Feed
March	1.	Joseph E. Brodie, Assistant Chemist,
April	1.	Lillian E. Gierman, Stenographer,
May	1.	Clara H. Wark, Laboratory Aid,
June	1.	Alice M. Welchman, Clerk.

Also during the year the following field and temporary helpers have been appointed:

A. L. Lea, Wilbur Burton, Stanley B. Douglass, John P. Hilgers, Wm. J. Masion, Wm. Brockman, Jas. C. Gillespie, Edward Johnstone, Geo. J. Maust, E. Tiel Smith, Edgar K. Walrath, Horace Lane, Ludwig Adam, Francis H. Bent, Jr., A. C. Clark, Joseph Cotter, Wm. F. Davis, Hyman Einstein, H. Stephen Ernhaut, Louis Goodman, Gerard Grady, Arthur Greenberger, Archibald Holden, Chas. M. Mulvey, Thomas H. Neill, Wm. L. Lester, John I. Saint, Francis Wood, L. Graham Campbell, George Adam, Wm. Baker, Harry O'Donnell, Chas. S. Sproul, Justin Voorhees, Arthur West, Herman R. Fletcher, Walter M. Debus, Ronald A. Nelson.

Resignations

July	31.	J. Marshall Hunter, Animal Husbandman,
August	31.	Emily G. Mershon, Stenographer,
September	30.	Beatrice Rodbortt, Mailing Clerk,
October	15.	Chas. H. Cane, Orchard Foreman,
	31.	F. Raymond Hunter, Assistant Chemist,
November	15.	Edson J. Currier, Assistant Chemist,
December	31.	W. Andrew Cray, Fertilizer and Feed Inspector,
January	15.	Carolyn N. Netzel, Statistician,
February	29.	J. Vincent Breazeale, Foreman, Vegetable Gardening,
		Eugene Beyer, Assistant in Vegetable Gardening,
		Lynton W. Hill, Head Dairyman.
March	31.	Elizabeth A. Christ, Stenographer,
		John P. Helyar, Seed Analyst,
April	30.	Mathilde Groth, Laboratory Aid,
May	31.	Grace B. Wobbe, Stenographer,
		Louise Treffinger, Stenographer,
June	30.	Madeleine B. Conlon, Telephone Operator,
		John Hill, Assistant Dairy Husbandman,
		Mitchell Carroll, Assistant Entomologist,
		Gertrude E. Macpherson, Research Assistant.

Deceased

November 21, 1919. Robert McIntire, Swineherd.

Also during the year the following field and temporary helpers have resigned:

A. L. Lea, Wilbur Burton, Stanley B. Douglass, Chas. B. Larcom, Wm. J. Masion, Wm. Riches, John Shackway, Wm. Brockman, Jas. C. Gillespie, Paul C. Hartman, Edward Johnstone, Geo. J. Maust, T. Montague Morgan, E. Tiel Smith, Leofric G. Temple, Edgar K. Walrath, E. S. Walrath, John G. Hubbard, Wm. Kammerer, Hugh E. Thompson, Field Assistant, J. Richards Nelson, Ludwig Adam, Francis H. Bent, Jr., Ralph Buttler, A. C. Clark, Wm. F. Davis, Gerard Grady, Arthur Greenberger, Antal Kiss, Frank Carpenter, Melvin Cosh, Wm. L. Lester, Frederick I. Morse, John I. Saint, Geo. J. Sullivan, Francis Wood, George Adam, Wm. C. Boughner, Harry O'Donnell, Justin Voorhees.

Transfers

[illegible] Owen, from Farm Superintendent to Extension Spe-
[illegible] in Poultry Husbandry.
R. Lane, from Farm Foreman to Farm Manager.
[illegible]nker, from Assistant Herdsman to Head Dairyman.

REPORT OF THE DEPARTMENT OF CHEMISTRY

Department of Chemistry

CHARLES S. CATHCART, M.SC., *Chemist.*

*JOSEPH E. BRODIE, B.SC., *Assistant Chemist.*

†LESTER R. SMITH, B.SC., *Assistant Chemist.*

RALPH L. WILLIS, B.SC., *Assistant Chemist.*

‡EDSON J. CURRIER, B.SC., *Assistant Chemist.*

§F. RAYMOND HUNTER, *Assistant Chemist.*

ARCHIE C. WARK, *Laboratory Assistant.*

FRANK S. BECKWITH, B.SC., *Fertilizer and Feed Sampler.*

**NOYES I. PURRINGTON, *Fertilizer and Feed Sampler.*

††W. ANDREW CRAY, *Sampler and Assistant.*

* Appointed March 1, 1920.
† Appointed November 1, 1919.
‡ Resigned November 15, 1919.
§ Resigned October 31, 1919.
** Appointed January 15, 1920.
†† Resigned December 31, 1919.

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Report of the Department of Chemistry

Charles S. Cathcart

I. INTRODUCTORY

The activities of the department of chemistry for the fiscal year nding June 30, 1920, have been largely confined to the inspection vork as prescribed by the laws regulating the sale of fertilizers, igricultural lime, insecticides and feeding stuffs. In addition to he regular inspection work, some analyses have been made for other lepartments but the amount of this work has been relatively small, ince the available time was limited.

II. ADMINISTRATION

During the year three members of the staff resigned and although heir successors were appointed as soon as possible the work was interfered with for a time until the new men became familiar with the letails relating to the work at hand. The inspections were completed, however, without serious delay and this condition was due to the nanner in which each member of the staff looked after the work issigned to him.

The laws regulating the sale of fertilizers, agricultural lime, inecticides and feeding stuffs require (1) an annual registration of the brands to be offered for sale and (2) the inspection of the brands found on the markets. In addition to these requirements, the fertilizer law and the feeding-stuffs law require semi-annual reports on he tonnage sold.

The following is a summary of the applications for registration which were received during the inspections that have been completed and for which certificates were duly issued:

Fertilizer registrations	1540
Agricultural lime registrations	72
Insecticide registrations	211
Feeding stuffs registrations	2507

During the year a total of 2,146 samples were examined and reports submitted to the manufacturers as well as to the parties whose stocks were represented by the samples. In order to render the reports on these samples it was necessary to make about 18,000 separate determinations.

The detailed results of the inspections were printed in the following bulletins:

Bulletin 337. Analyses of Commercial Fertilizers, Fertilizer Supplies and Home Mixtures.
Bulletin 339. Analyses of Materials Sold as Insecticides and Fungicides During 1919.
Bulletin 340. Analyses of Commercial Fertilizers and Ground Bone—Analyses of Agricultural Lime.
Bulletin 341. Fertilizer Registrations for 1920.
Bulletin 342. Analyses of Commercial Feeding Stuffs and Registrations for 1920.

III. INSPECTION OF COMMERCIAL FERTILIZERS

The detailed results of the fertilizer inspection were published in Bulletins 337 and 339.

Authority for Making the Inspection

The law entitled "An Act Concerning Fertilizers," approved March 27, 1912, requires mixed fertilizers and fertilizer materials to be sold under prescribed regulations, and also requires an annual inspection of the materials sold. During the 1919 session of the Legislature the law was amended, making an additional requirement of the payment of a nominal registration fee and also changing the form of penalty for the violation of any of the provisions of the law. A copy)f the amended law will be forwarded upon request.

Registrations

During the year 130 manufacturers and jobbers registered 1,540)rands of mixed fertilizers and fertilizer materials.

It is necessary to publish the various registrations made and, ac-:ordingly, under date of January 30, 1919, Bulletin 335 was issued :ontaining all of the registrations which had been received up to hat date. The registrations that were received after that date for the iscal year ending October 31, 1919, were published in Bulletin 340.

Bulletin 341 was published under date of January 26, 1920, and ontained the registrations made since November 1, 1919.

Reports of Tonnage

The law requires the manufacturers or parties responsible for the sale of fertilizers in this state to render on April 1 and November 1 of each year a certified report of the tonnage sold during the preceding months. The reports were duly rendered. Table 1 shows the tonnage reported during the last seven years.

Table 1

Summary of Tonnage Reports

YEAR	*April Reports*		*November Reports*		
	Mixed Fertilizers	Fertilizer Materials	Mixed Fertilizers	Fertilizer Materials	Total for the Year
	Tons	Tons	Tons	Tons	Tons
1913	87,446.91	10,303.17	51,706.28	7,204.79	156,661.15
1914	78,768.27	8,735.62	59,223.26	8,686.28	155,414.14
1915	87,052.13	7,276.45	53,288.11	5,459.28	153,075.97
1916	61,369.88	9,032.68	52,328.81	7,069.81	129,800.07
1917	86,840.44	9,146.80	74,231.13	6,264.73	176,483.10
1918	90,371.85	6,544.66	51,404.20	4,877.90	153,198.61
1919	94,463.07	6,264.86	43,594.97	5,162.15	149,485.05

Wholesale Prices of the Essential Elements of Plant-Food for 1919

The wholesale prices of the unmixed or raw materials used in preparing the mixed fertilizers are quoted weekly in the trade journal, "The Oil, Paint and Drug Reporter." In order to express the figures given as prices per pound of actual plant-food, which is the form adopted by the experiment stations of this country, the quotations have been recalculated and tabulated for the year 1919.

Collection of Samples

The official collection of the samples of the fertilizers sold was made by our two inspectors who were given itineraries which had been care-

During these tours, the inspectors visited every county in the state and a total of 1,672 samples were received at the station, all but a small percentage of which were officially drawn. These samples represented the stock of 584 dealers and consumers who were located in 220 different cities and towns. The stock of many other dealers and consumers was inspected, but no samples were taken because the brands had been previously sampled at nearby places.

The samples that were forwarded by individuals were duly examined and reported, but the results have not been tabulated unless they were considered of sufficient public interest or it was desired to make a permanent record of the results.

Table 2

Wholesale Cost, Per Pound, in New York

MONTHS 1919	Of nitrogen in the form of			Of Phosphoric Acid in the form of	Of Potash in the form of	
	Nitrate of Soda	Sulfate of Ammonia	Dried Blood	Acid Phosphate	Muriate of Potash	Sulfate of Potash
	cents	cents	cents	cents	cents	cents
January	28.24	23.37	38.31	6.07	25.72	29.56
February	28.24	22.68	35.82	6.07	25.72	28.28
March	26.16	21.95	32.79	6.00	25.72	26.22
April	26.01	21.95	30.36	5.71	25.72	23.14
May	26.01	21.95	31.12	5.54	.....	.....
June	24.63	21.27	31.57	5.68	11.22	15.00
July	18.89	20.37	33.24	5.94	10.14	.....
August	18.76	20.19	40.29	6.25	11.87	.....
September	18.64	18.63	44.93	6.43	11.28	.....
October	18.64	19.22	44.02	6.43	11.28	.....
November	19.18	21.25	44.02	6.43	12.37	.....
December	19.30	32.05	44.02	6.88	13.80	.....
Average, 1919	22.73	22.13	37.54	6.12	15.40	.....
Average, 1918	30.17	32.82	42.04	6.36	31.02	.....
Average, 1917	26.18	29.17	33.66	5.24	.....	.....

This department has for the past few years advised the individuals not to send samples of their purchases, but if they desired to have an examination made, to notify us, giving the fnll information regarding the material, including the brand name, the guarantee and the manufacturer's name and address. Upon receipt of this request arrangements will be made to have a sampler call and take the sample without any cost to the party making the request, provided the amount of stock on hand warrants the extra labor. The reason for

this is that usually the purchaser is not prepared to take a sample that would represent the shipment and unless the sample does represent the shipment, the results obtained by the chemical examination would not have much value. The necessity for making the request for the full information is questioned by some people, who claim that it is not our business to require such statements and that, if given, the report will be based upon the statements made and not upon chemical analyses. This criticism is unfair, since it is one of our duties to ascertain whether or not every brand of fertilizer sold is registered and properly branded, and without this information we would not know whether or not the law was being complied with. In regard to the effect upon the report, the information is filed in the office and does not reach the laboratories and consequently has no bearing on the results obtained. It is our endeavor to give as much assistance as possible and it is quite apparent that in order to render this assistance to the greatest number it is necessary to secure detailed information regarding each new question raised.

Official Samples Selected for Examination

The law definitely prescribes the method to be used in sampling fertilizers, and the inspectors are given definite instructions regarding the same. It would be impossible to examine all of the samples that could be obtained and consequently the inspectors have instructions as to the number of samples of each particular brand which they should sample. As a result, nearly every brand is represented by two or more samples. Every brand received is examined. If only one sample of a brand has been received there can be no selection, but when more than one sample has been received, it is our practice to select the one that represented the largest stock on hand at the time of sampling. The samples analyzed during the present year consisted of the following:

556 samples of commercial fertilizers.
100 samples of commercial fertilizers (duplicates).
8 samples of home mixtures.
11 samples of humus and manures.
127 samples of fertilizer materials.
40 samples of ground bone.
234 samples of sundry materials.

1085 samples, total.

The Chemical Examination

Commercial fertilizers are usually prepared by the use of a number of different materials, and consequently the determination of the total quantities of the elements present does not give sufficient information in order to judge the true value of the mixture. Realizing this con-

dition, it is the practice of the station to determine the forms of the elements as well as to determine the total amounts present. In order to get this detailed information it is necessary to make determinations of the following:

Nitrogen—as nitrates; as ammonia salts; as soluble and insoluble organic, and the availability of the insoluble portion.

Phosphoric Acid—as water-soluble; as ammonium-citrate-soluble, or reverted; as insoluble; and total. The sum of the water-soluble and ammonium-citrate-soluble, or the difference between the total and insoluble, is called available.

Potash—soluble in water and whether it is in the form of muriate or sulfate.

The cost of fertilizers makes it necessary for each purchaser to examine carefully the character of the fertilizers, and consequently a study of the results should prove profitable.

Average Guaranteed and Actual Composition

The total number of samples of mixed fertilizers examined was 665, representing 556 brands. There were 284 brands that were guaranteed to contain nitrogen, phosphoric acid and potash and in the other 272 brands potash was not guaranteed.

Table 3

Average of 284 Brands Containing Nitrogen, Phosphoric Acid and Potash

	Average		
	Found		Guaranteed
	per cent	per cent	per cent
Nitrogen, as nitrates	0.49	....	....
Nitrogen, as ammonia salts	0.63	....	....
Nitrogen, as water-soluble organic	0.29	....	....
Nitrogen, as water-insoluble organic	0.69	....	....
Nitrogen, total	....	2.10	2.12
Phosphoric acid, total	10.03	....	....
Phosphoric acid, insoluble	1.45	....	....
Phosphoric acid, available	....	8.58	8.45
Potash	....	2.24	2.15

By referring to tables 3 and 4, it will be noted that the average composition of the samples examined was substantially equal to the guarantees as given, the average content of nitrogen being somewhat less and the average content of phosphoric acid and potash larger

Table 4

Average of 272 Brands Containing Nitrogen and Phosphoric Acid

	Average		
	Found		Guaranteed
	per cent	per cent	per cent
Nitrogen, as nitrates	0.41	....	....
Nitrogen, as ammonia salts	0.84	....	....
Nitrogen, as water-soluble organic	0.34	....	....
Nitrogen, as water-insoluble organic	0.85	....	....
Nitrogen, total	....	2.44	2.52
Phosphoric acid, total	11.49	....	....
Phosphoric acid, insoluble	1.62	....	....
Phosphoric acid, available	....	9.87	9.60

than the average guarantees. When the detailed results are examined, it will be found that a number of the brands exceeded the guarantees and this fact in connection with the average content of nitrogen will call attention to the number of brands that were de-

Table 5

Comparison of Deficiencies from 1909 to 1919

YEAR	Number of Brands				Deficiencies Possible	Actual Deficiencies			
	Examined	Found as Guaranteed	Found Deficient	Percentage Deficient		Nitrogen	Phosphoric Acid	Potash	Percentage
1909	483	280	203	42	1,449	71	137	36	16.8
1910	520	316	204	39	1,560	51	142	45	15.3
1911	514	341	173	34	1,542	36	115	42	12.5
1912	536	326	210	39	1,608	47	146	33	14.1
1913	623	457	166	28	1,869	74	86	36	10.5
1914	608	420	188	31	1,824	63	92	49	11.2
1915	543	367	176	32	1,629	94	83	31	12.8
1916	565	356	209	37	1,406	139	81	17	16.9
1917	552	380	172	31	1,360	85	88	15	13.8
1918	502	352	150	30	1,218	82	69	15	13.6
1919	556	388	168	30	1,396	98	73	17	13.5

ficient in nitrogen, the most costly element in a fertilizer. The records show that 130 brands fully sustained their guarantees and that 258 brands were substantially in the same class. There were 168, or 30 per cent, deficient brands, 149 being deficient in one element, 18 in two elements and 1 in three elements.

In order to compare the deficiencies with those of preceding years table 5 has been prepared. In preparing this tabulation, deficiencies of 0.20 per cent or less of nitrogen and 0.30 per cent or less of phosphoric acid and potash have been disregarded.

In the 556 brands examined there was 1,396 deficiencies possible, and of this number 188, or 13.5 per cent, were found. These deficiencies consisted of the following: nitrogen 98, phosphoric acid 73 and potash 17.

The average composition of the mixed fertilizers taken as a whole compares very favorably with the record for the past two years but there was a percentage increase in the number of brands deficient in nitrogen which balanced in number the smaller percentage of brands that were deficient in phosphoric acid and potash. It is needless to say that this record is not one that can be quoted as ideal when nearly one-third of the brands are deficient.

Quality of the Plant-Food

A knowledge of the content of total nitrogen, available phosphoric acid and water-soluble potash in a fertilizer is essential, but it does not show the quality of all of the plant-food contained, particularly in regard to the nitrogen content. The total nitrogen as found in the fertilizers may be derived from many sources, some of which are of high grade while other sources are known to have but little value. Many of these latter sources may be made available, however, by proper treatment at the factory. There is no question regarding the high availability of the nitrogen in mixed fertilizers when it is present as nitrates, as ammonia salts and as water-soluble organic, but the value of the insoluble organic form depends upon its source and the method of treatment at the factory. The crop-producing power may also depend upon the relative proportions of these different forms even if all of the materials are of good quality. On account of these conditions the reports should be carefully studied in order to know the true value of the mixture. All the brands of mixed fertilizers were examined in order that this information may be given. The results show that 261 brands contained nitrogen in the form of nitrates, 373 brands contained ammonia salts and 165 brands contained both of these forms of nitrogen. Almost all of the brands contained water-soluble organic nitrogen, although in some cases the amount was very small. The insoluble organic nitrogen was determined in each sample and also the availability of this form was ascertained. The results of these determinations show that 126, or 22.6 per cent, of the brands contained an inferior grade of organic

nitrogen. Fifty of these brands contained more total nitrogen than was guaranteed. The excess was sufficient in 26 cases partially to offset, and there were 24 cases where the excess was sufficient entirely to offset, the amount of inferior quality. These figures, when compared with the results obtained last year, will show that a larger number, about 6 per cent, of the brands were found to contain an inferior grade of organic nitrogen. This is a serious condition and should be given careful consideration, since it means that the amount of available nitrogen supplied to the crops was less than was intended. There is also a considerable difference in the money value, since the market quotation of the high-grade materials is about twice as much as that of the low-grade materials.

The available phosphoric acid as reported is considered to be readily available to the growing crops and consists of two forms of phosphoric acid, one portion being soluble in water and the other in ammonium-citrate solution. The water-soluble portion can be more widely distributed in the soil than the other form.

The potash content as reported is soluble in water and is readily available.

Table 6

Average Composition of Ground Bone for Ten Years

YEAR	Fine	Coarse	Nitrogen	Phosphoric Acid	Valuation	Selling Price
1910	66	34	2.77	24.27	$28.70	$29.83
1911	65	35	2.64	23.11	27.31	28.09
1912	57	43	2.90	22.89	27.73	31.12
1913	60	40	2.83	23.53	27.62	32.44
1914	60	40	2.82	23.24	29.97	32.40
1915	57	43	2.96	23.77	29.24	33.50
1916	53	47	2.80	23.80	.....	39.50
1917	58	42	2.95	24.28	.....	38.32
1918	59	41	2.85	24.84	.....	48.49
1919	58	42	2.93	24.82	.....	54.71

Station's Valuation and Selling Price

Valuations for the various brands were not calculated on account of the wide fluctuations in the market quotations. This is shown by making averages of the selling prices per ton of spring shipments and of fall shipments. These averages are as follows:

	Spring	Fall
Fertilizers containing nitrogen, phosphoric acid and potash..	$58.73	$36.72
Fertilizers containing nitrogen and phosphoric acid........	49.64	33.88

Table I

Summary of the Results Obtained with the Mixed Fertilizers Examined During the Inspection of 1919

MANUFACTURER	Address	Number of Brands Received	Number of Samples Examined	Number of Samples that Satisfied Guarantees	Number of Samples that Substantially Satisfied Guarantees*	Number of Samples Deficient in—					
						Nitrogen	Phosphoric Acid	Potash	One Element	Two Elements	Three Elements
Acme Guano Co.	Baltimore, Md.	8	9	....	....	6	4	2	7	1	1
Active Chemical Co.	Camden, N. J.	13	17	4	3	7	7	2	5	4	1
American Agricultural Chemical Co.	New York City	86	98	26	59	9	3	1	13	...	...
American Fertilizing Co.	Baltimore, Md.	6	7	2	4	1	...	...	1	...	...
Armour Fertilizer Works	Baltimore, Md., and Chrome, N. J.	10	11	4	6	1	...	...	1	...	...
J. H. Baird & Son	Marlboro, N. J.	1	1	....	1	...	...	...	...	...	...
Baltimore Pulverizing Co.	Baltimore, Md.	3	4	....	2	1	1	...	2	...	...
Baugh & Sons Co.	Philadelphia, Pa.	17	25	5	17	2	1	...	3	...	...
Bennett & Bennett	Prospect Plains, N. J.	1	1	....	....	...	1	...	1	...	...
The Berg Co.	Philadelphia, Pa.	4	5	2	2	1	...	...	1	...	...
Berger Bros.	*Easton, Pa.*	1	1	....	1	...	...	...	...	...	...
Bowker Fertilizer Co.	New York City	16	20	6	9	3	2	...	5	...	...
William M. Brown & Son	Cedarville, N. J.	4	4	....	3	...	1	...	1	...	...
Central Chemical Co.	Hagerstown, Md.	2	2	....	....	2	...	...	2	...	...
Chamberlain & Barclay	Cranbury, N. J.	3	3	....	2	1	...	...	1	...	...
Coe-Mortimer Co.	New York City	13	17	9	7	1	...	...	1	...	...
J. S. Collins & Son, Inc.	Moorestown, N. J.	2	2	....	1	1	...	...	1	...	...
Consumers Chemical Corporation	New York City	8	11	4	4	...	3	...	3	...	...
James G. Downward Co.	Coatesville, Pa.	2	2	....	....	2	2	...	...	2	...
Farmers' Cooperative Association	Trenton, N. J.	8	13	6	5	1	1	...	2	...	...
Alex. Forbes & Co.	Newark, N. J.	2	2	....	....	...	2	...	2	...	...
Forman & Dilatush	Dayton, N. J.	2	2	....	1	1	...	...	1	...	...
Godfrey Cooperative Fert. & Chem. Co.	Newark, N. J.	15	16	....	11	3	2	...	5	...	...
Thomas Y. Hackett	*Daretown, N. J.*	2	2	2	....	...	...	...	...	...	...
Hendrickson & Dilatush	Robbinsville, N. J.	5	5	3	1	1	...	...	1	...	...
Heritage & Bros.	Mullica Hill, N. J.	5	7	2	3	2	1	...	1	1	...
S. M. Hess & Bros., Inc.	Philadelphia, Pa.	11	14	3	10	1	...	...	1	...	...
Thomas Hill	Flemington, N. J.	1	1	....	1	...	...	...	...	...	...
Hill Bros.	Flemington, N. J.	3	4	1	3	...	...	...	...	...	...
P. H. Hoffman & Bro.	Raubsville, Pa.	1	1	....	....	1	...	...	1	...	...
Hutchinson & Rue	Windsor, N. J.	1	1	1	....	...	...	...	...	...	...

MANUFACTURER	Address	Number of Brands Received	Number of Samples Examined	Number of Samples that Satisfied Guarantees	Number of Samples that Substantially Satisfied Guarantees*	Number of Samples Deficient in— Nitrogen	Phosphoric Acid	Potash	One Element	Two Elements	Three Elements
Locke & Black	*Swedesboro, N. J.*	6	6	2	2	1	1	...	2	...	...
Mapes F. & P. Guano Co.	New York City	6	7	....	1	...	6	1	5	1	...
Martin Fertilizer Co.	Philadelphia, Pa.	10	10	1	5	3	...	1	4	...	...
Monmouth County Farmers' Exchange	Freehold, N. J.	4	5	2	2	...	1	...	1	...	...
J. R. Moore	Swedesboro, N. J.	6	6	1	4	1	...	...	1	...	...
Nassau Fertilizer Co.	New York City	5	7	3	4	...	...	...	...	...	...
Albert Nelson	Allentown, N. J.	5	6	2	2	1	1	...	2	...	...
Nitrate Agencies Co.	New York City	2	2	....	....	1	...	1	2	...	...
L. A. Page	Beverly, N. J.	1	1	....	....	...	1	...	1	...	...
Patapsco Guano Co.	Baltimore, Md.	1	1	....	1	...	...	...	...	...	...
Philadelphia Guano Works	Philadelphia, Pa.	8	10	1	4	2	3	1	4	1	...
Rasin-Monumental Co.	Baltimore, Md.	14	18	5	13	...	...	...	...	...	...
Reading Bone Fertilizer Co.	Reading, Pa.	2	2	....	1	1	...	...	1	...	...
Robert A. Reichard	Allentown, Pa.	2	2	....	....	1	1	...	2	...	...
F. S. Royster Guano Co.	Baltimore, Md.	11	18	1	8	6	7	...	5	4	...
Ruckman Bros.	New Brunswick, N. J.	2	2	1	....	1	...	...	1	...	...
Schanck, Hutchinson & Field	Hightstown, N. J.	2	2	1	1	...	...	...	...	...	...
Scott Fertilizer Co.	Elkton, Md.	5	6	1	2	1	2	...	3	...	...
T. Serata & Sons	Bridgeton, N. J.	4	4	....	3	1	...	...	1	...	...
M. L. Shoemaker & Co., Inc.	*Philadelphia, Pa.*	3	4	2	....	1	1	...	2	...	...
Harry L. Sickel	Woodbury, N. J.	2	2	....	2	...	...	...	...	...	...
South Jersey Farmers' Exchange	Woodstown, N. J.	25	30	5	15	5	6	1	8	2	...
Standard Guano Co.	Baltimore, Md.	9	9	2	3	3	...	1	4	...	...
Swift & Co.	Baltimore, Md.	9	9	....	4	5	...	1	4	1	...
Swift & Co.	Kearny, N. J.	17	20	2	9	5	5	1	7	2	...
I. P. Thomas & Sons Co.	Philadelphia, Pa.	26	33	7	10	9	7	1	15	1	...
Trenton Bone Fertilizer Co.	Trenton, N. J.	15	17	2	4	9	3	...	10	1	...
F. W. Tunnell & Co., Inc.	Philadelphia, Pa.	24	33	6	17	4	4	4	8	2	...
J. E. Tygert Co.	Philadelphia, Pa.	5	7	2	2	2	1	...	3	...	...
Virginia-Carolina Chemical Co.	New York City	22	22	9	10	3	...	...	3	...	...
West Jersey Marl & Transportation Co.	Woodbury, N. J.	9	9	1	6	1	1	...	2	...	...
W. E. Whann Co.	Philadelphia, Pa.	3	3	....	2	...	1	...	1	...	...
William Wilde	Vineland, N. J.	3	3	1	2	...	...	...	...	...	...
J. R. Wyckoff	Princeton Jct., N. J.	4	4	1	1	...	2	...	2	...	...

Ground Bone

Forty samples of ground bone were examined during the inspection and the results are given in Bulletin 340.

Table 6 gives the average composition of ground bone for the past ten years.

IV. AGRICULTURAL LIME

During the past year 35 manufacturers registered 72 different brands of agricultural lime. The names and address of those who have registered their products are given in Bulletin 342.

Inspection

A comparatively large number of samples of the lime products were received and duly reported. The detailed results obtained with the official samples were published in Bulletin 340.

V. INSPECTION OF INSECTICIDES

The inspection of the insecticides sold in this state during the past season was made under the authority of the law entitled "An Act to Regulate the Sale of Insecticides" (Chapter 89, Session of 1912), and the results obtained were published in Bulletin 339.

The purpose of this law is to prevent the sale of misbranded or adulterated materials that may be used in "preventing, destroying repelling or mitigating any insects which may infest vegetation." In order to accomplish this purposee the party responsible for the *material is required to register the brands that will be offered for* sale, this registration including the name and address of the manufacturer, the minimum amount of total arsenic and the maximum amount of water-soluble arsenic which the insecticide contains; or if the material does not contain arsenic, the professed standard must be stated. The statements that are registered must be attached to the materials as sold.

Registrations

In accordance with the requirements of the law, 47 manufacturer and dealers registered 211 brands, as listed in Bulletin 339.

Collection of Samples

Insecticides are sold in large shipments and also in smaller packages. It has been our practice to secure samples from the large shipments as well as from the smaller original packages in order that full and complete information may be secured relative to the character of the materials being sold.

Inspection

One hundred and three samples were collected during the inspection and they represent every brand that could be located. At least one sample of each brand was examined in order to ascertain whether the guarantees had been sustained, and in some instances additional samples were examined.

The total number of samples examined is as follows:

15	samples of Paris Green
7	samples of Lead Arsenate (Paste)
20	samples of Lead Arsenate (Powder)
10	samples of Bordeaux Mixture
6	samples of Lime-Sulfur Solution
5	samples of Soluble-Sulfur Compounds
4	samples of Nicotine Preparations
33	samples of Miscellaneous Brands
100	Total

Paris Green

Fifteen samples of paris green are reported, ten of which were received in original packages. The samples received in original packages were carefully weighed with and without the container and all of the packages were found to contain the full weight of the insecticide claimed.

According to the law the standard for paris green is that it should not contain less than 50 per cent of arsenious oxide and should not contain arsenic in water-soluble forms equivalent to more than 3.50 per cent of arsenious oxide. All of the samples examined fulfilled these requirements.

The ratio of copper oxide to arsenious oxide in pure paris green is 1 to 1.87. In order to determine the purity of the samples examined the ratio was computed and it was found that 4 samples gave a wider ratio than is found in a pure product. This result would indicate that these samples contained some arsenic which was not combined with the copper.

Lead Arsenate

There were 7 samples of lead arsenate paste examined, four of which were obtained in original packages; they contained the net weight of material claimed.

The standard for this material is (1) not more than 50 per cent of water, (2) not less than 12.50 per cent of arsenic oxide and (3) water-soluble arsenic equivalent to less than 0.75 per cent of arsenic oxide. All of the samples satisfied these requirements with the exceptic

Bordeaux Mixture

A total of 10 samples of bordeaux mixture, five of which were in a dry form, were examined. All of the samples satisfied the guarantees given with the exception of one sample which contained 0.45 per cent less metallic copper than was guaranteed.

Lime-Sulfur Solution

Six samples of lime-sulfur solution were examined, five of which satisfied the guarantees given. The deficient sample contained 23.57 per cent of total sulfur and was guaranteed to contain 24 per cent.

Soluble-Sulfur Compounds

Two classes of materials were represented by the 5 samples examined. *The total content of sulfur varied from 44.11 to 61.65 per cent.*

Lime-Sulfur Solution and Its Substitutes

Lime-sulfur solution is a bulky material and the average 33° Beaumé solution consists of about 25 per cent of sulfur, 10 per cent of lime and 65 per cent of water. On account of its mechanical condition, the purchaser is required to pay freight and cartage charges on a large quantity of water which could be obtained at the farm without much cost. It would appear that if the material could be prepared and sold in a dry form a considerable saving in cost would be made.

Within the past few years attempts have been made to prepare a *substitute in dry form to replace the familiar lime-sulfur solution*; at the present time there are a few of these brands available but there is no record as to the relative quantity sold. Reports have been received by this department to the effect that some of the manufacturers of the lime-sulfur solution will not offer this material for sale in the future, but will offer the dry substitute. Since this is the case the value of these dry forms should be carefully studied in order to ascertain how they compare, in efficiency and cost, with the materials obtained in solution.

There are three classes of substitutes on the market which are sold as (1) *soluble-sulfur* compound, (2) dry lime-sulfur and (3) B. T. S. The soluble-sulfur compound wa
it is not a compound of sulfur and l

summer spray in combination with lead arsenate, as a soluble arsenate is likely to be formed which would cause burning of the foliage. The dry lime-sulfur is practically the lime-sulfur solution dried. The B. T. S. is a combination of barium and sulfur.

The following tabulations have been prepared by the use of the figures and recommendations furnished by the manufacturers, the prices given being f. o. b. factory. It has been assumed that the total content of sulfur in the dry forms is entirely soluble in water, but as a matter of fact this assumption is not correct, since there is always a portion of the material that is not soluble which all of our tests have shown to be sulfur. The amount of this free sulfur is variable and for the purpose of this comparison may be neglected.

The following tabulation shows the materials used in the comparison as well as the average composition, average selling prices and the calculated cost of total sulfur per pound of the material:

Material	*Total* Sulfur	Average Price per Pound	Calculated *Cost of* Total Sulfur per Pound
	Per cent	Cents	Cents
Lime-Sulfur Solution	25.0	1.75	7.0
Soluble-Sulfur Compound	58.0	9.0	15.5
Dry Lime-Sulfur	57.0	14.0	24.6
B. T. S.	44.4	12.0	27.0

The above tabulation shows very clearly the cost of the total sulfur per pound in the four compounds enumerated but this information considered by itself does not have much value. The manufacturers recommend a certain amount of their materials to be used in preparing the mixture. In accordance with these directions the following tabulation was prepared, which shows the quantity recommended, the amount of total sulfur that would be in the mixture and the cost of the material in 50 gallons of the spraying mixture:

Material	Pounds Recommended	Pounds of Total Sulfur	Cost of Materials Used
Lime-Sulfur Solution	75.0	18.75	$1.31
Soluble-Sulfur Compound	12.5	7.25	1.13
Dry Lime-Sulfur	14.0		

The difference in the cost of the different materials for making the mixtures was not very great, although there is an increase with the dry lime-sulfur and B. T. S. The great difference in the mixture is shown by the figures giving the amounts of total sulfur contained. Assuming that it is necessary to use the amount of lime-sulfur solution recommended, it follows that the same amount of total sulfur *should be obtained from the substitutes in order to get the desired* results.

The followiug tabulation gives the weight of the substitutes that should be used in order to furnish the same amount of total sulfur as derived from 75 pounds of lime-sulfur solution, and also shows the cost of the materials when such quantities are used:

Materials	Pounds of Materials	Per Cent of Total Sulfur	Cost of Materials
Lime-Sulfur Solution	75.0	18.75	$1.31
Soluble-Sulfur Compound	32.3	18.75	2.90
Dry Lime-Sulfur	32.9	18.75	4.61
B. T. S.	42.2	18.75	5.06

From the above it is quite apparent that if these substitutes are used in the amounts stated, the cost of the materials is much greater than if the lime-sulfur solution had been the active ingredient employed, the increase being from $1.31 to $5.06, or a maximum difference of $3.75 for each 50 gallons prepared.

If it is desired to know the relative cost of the materials delivered to the purchaser the figures can be secured by adding the freight charges of the actual amount used to the cost as tabulated. The delivered cost of the lime-sulfur solution would be $1.31 plus the freight on 75 pounds, the cost of the soluble-sulfur compound would be $2.90 plus the freight charges on 32.3 pounds, etc. The difference in this increase, however, is relatively small and it would not materially affect the relation of the cost as shown.

Conditions may be found where the application of the substitutes as recommended by the manufacturers is sufficient and in such cases 28.5 pounds of lime-sulfur solution would furnish an equivalent amount of total sulphur. The cost of such mixtures would be as follows:

Lime-Sulfur Solution................................	$0.50
Soluble Sulfur Compound............................	1.13
Dry Lime-Sulfur	1.96
B. T. S.	1.68

Under such conditions the actual cost would be greatly reduced but the relative difference still remains.

The fruit grower should carefully consider whether the convenience of the dry substitute is worth the difference in the cost.

Nicotine Preparations

The tobacco products were represented by 4 samples. All of the samples satisfied the guarantees given.

Miscellaneous Brands

There were 33 samples examined which represented materials sold under distinctive brand names. Twenty-five of the samples satisfied the guarantees given. There were 12 deficiencies found in 8 samples and they consisted of 6 in the total arsenic, 5 in the water-soluble arsenic and 1 in the sulfur content.

VI. INSPECTION OF COMMERCIAL FEEDING STUFFS

The law entitled "An Act Concerning Commercial Feeding Stuffs" requires an annual inspection of these materials sold in this state and the publication of the results obtained. In accordance with these requirements the inspection was made and the results obtained were published in Bulletin 342.

The Feedings-Stuffs Law

During the 1919 session of the Legislature the law as approved on March 28, 1912, was amended. These amendments, however, do not remove any of the requirements as enumerated in the original law. The amendments, briefly stated, require a registration fee of fifty cents per brand (section 3) and change the penalty for violation of the law from a misdemeanor to a stated fine (section 10). The requirements in the amended law are:

1. An annual registration giving the guaranteed composition which will be attached to the materials as sold and the payment of a registration fee at the rate of fifty cents per brand.
2. The inspection of the feeds sold and the publication of the results obtained.
3. Fixed the penalty for any violation of the law at $100.00 for the

Those interested in the manufacture, sale or use of feeds should b familiar with the details of the various requirements enumerated The full text of the law has been published and is available in circula form, and a copy will he sent on request.

Registrations

During the year 1919, 420 manufacturers and jobbers registere 2,507 brands which they desired to sell in this state. A number of th local manufacturers did not register their brands on account of th high cost of the ingredients required and the difficulty in securin them when needed. The total number of brands that were registered however, was undoubtedly sufficient to meet the needs of all of th feeders in the state.

The inspectors found 42 brands that were being sold before the were registered. There is no excuse for this condition other than neg ligence of the shipper, since most of the brands had been previousl registered. There were a few cases where local manufacturers had ne brands and who claimed ignorance of the law. All of these brands with a very few exceptions, were registered after attention had bee called to the necessity of fulfilling this requirement.

Tonnage of Feeding-Stuffs Sold

Manufacturers and those responsible for feeding stuffs sold in thi state are required to render reports on July 1 and January 1 of eac year, showing the total tonnage sold during the 6 months precedin these dates. Table 8 is a summary of the reports received during th past 7 years.

Table 8

Summary of Tonnage Reports

YEAR	July Reports	January Reports	Total for Year
	Tons	Tons	Tons
1913	93,664.17	102,560.00	196,224.17
1914	88,192.50	114,508.73	202,701.23
1915	103,626.91	124,563.34	228,190.25
1916	111,910.84	123,437.16	235,348.00
1917	114,939.37	119,101.06	234,040.43
1918	108,771.45	121,635.23	230,406.68
1919	102,837.34	144,052.15	[illegible]

Inspection

The inspection during the past year was conducted in the same general manner as during previous years. Two inspectors are engaged in this work and it is their duty to ascertain whether the shipments have been properly registered and branded, as well as to secure samples which are forwarded to the station for examination. It is impossible to collect samples of every brand that is registered but samples are taken of every brand located.

The itinerary furnished the inspectors included every county in the state and 1,096 samples were secured from the stock of 270 dealers and consumers who were located in 155 different cities and towns. The stocks of many other dealers and consumers were inspected in regard to the registration and statement of guarantees, but no samples were taken, since the same brands had been sampled at nearby places.

Results of the Chemical Examination

During the inspection 826 of the samples collected by our inspectors were examined and the results obtained together with the ingredients guaranteed are tabulated in Bulletin 342. In addition to these official samples, 109 samples were forwarded by individuals. All of these unofficial samples were examined and the reports sent to the parties interested.

There were a few samples collected which were not accompanied by the required guarantees, but this omission was attended to by the seller after the condition had been reported.

From the examination of the guaranteed samples it was found that 171, or 20.8 per cent, did not substantially satisfy the guarantees given for protein, fat or fiber. The deficiencies found consisted of the following: protein 66, fat 59, and fiber 78. There were 141 samples deficient in one nutrient, 28 deficient in two nutrients and 2 deficient in the three nutrients. The New Jersey manufacturers are credited with 189 brands and of this number 53, or 28 per cent, are deficient. The number of deficient samples representing shipments from other states is 118, or 18.6 per cent.

A comparison of the number of deficiencies found during the last 7 inspections is given in table 9, and it will be noted that there was a perceptible improvement over the report for 1919; in fact, it is the best showing since 1915.

Table 9

Summary of Deficiencies

INSPECTION	Samples Examined	Samples Deficient	Samples Deficient in—		
			Protein	Fat	Fiber
		per cent	per cent	per cent	per cent
1914	740	17.7	8.2	5.4	7.2
1915	920	17.2	6.7	6.8	6.6
1916	1102	26.6	9.3	9.3	14.0
1917	1103	32.3	10.0	9.3	19.6
1918	932	27.9	9.3	8.9	16.2
1919	810	22.1	9.6	4.6	12.0
1920	822	20.8	8.0	7.2	9.2

Table 10

Comparison of the Average Retail Selling Prices

	Average Per Ton During the Inspection of				
	1916	1917	1918	1919	1920
Alfalfa Meal	$31.78	$32.50	$47.00	$51.00	$56.50
Brewers' Dried Grains	29.25	29.41	52.80	63.80	66.20
Buckwheat Feed	25.93	39.00	54.00	59.00	61.25
Buckwheat Middlings	29.00	34.00	51.22	54.40	53.40
Cocoanut Meal	28.00	33.00	48.00	54.00	68.00
Corn Feed Meal	33.22	40.33	81.10	66.20	75.33
Corn Gluten Feed	30.11	36.30	59.28	58.00	74.40
Cottonseed Meal	37.75	46.91	59.00	65.00	85.35
Dried Beet Pulp	27.25	37.00	49.25	53.00	58.33
Hominy Feed	31.73	40.40	65.43	68.40	67.30
Linseed Oil Meal	43.38	44.12	60.07	63.80	83.45
Malt Sprouts	28.17	32.00	44.50	61.40	62.67
Meat Meal	57.30	58.00	96.40	109.00	105.80
Rye Bran	26.33	29.57	42.80	[illegible]	[illegible]
Rye Feed	[illegible]	[illegible]	[illegible]		

Table 11

Summary of the Results of the Inspection

EEDING STUFF	Number of Samples Examined	Average Composition: Moisture	Average Composition: Protein	Average Composition: Fat	Average Composition: Fiber	Average Retail Selling Price Per Ton	Number of Samples that Satisfied Guarantees	Number of Samples Deficient in— Protein	Fat	Fiber	One Nutrient	Two Nutrients	Three Nutrients
Alfalfa Meal	7	7.45	15.22	1.74	28.65	$56.50	5	....	....	1	1	....	....
Brewers' Dried Grains	13	6.72	26.00	6.83	13.13	66.20	8	5	1	2	2	3	....
Buckwheat Feed	6	13.70	22.86	5.95	3.13	61.25	2	3	1	1	3	1	....
Buckwheat Middlings	7	13.55	30.32	8.28	4.21	53.40	5	1	....	....	1	....	....
Buckwheat Offal	6	9.75	17.45	4.51	16.51	40.80	3	2	....	3	1	2	....
Calf Meal	4	......	......	......	......	109.50	2	1	2	....	1	1	....
Cocoa Bean Shell Meal	1	8.35	14.81	7.72	14.16	......	......	....	1	....	1	....	....
Cocoanut Oil Meal	1	7.68	22.50	15.24	9.60	68.00	1	....	....	....	....	....	....
Cottonseed Feed	3	10.30	20.96	4.36	22.43	66.67	3	....	....	....	....	....	....
Cottonseed Meal	17	6.87	37.62	7.46	10.71	85.35	13	3	....	2	3	1	....
Corn Feed Meal	3	11.44	8.96	3.95	1.75	75.33	3	....	....	....	....	....	....
Corn and Cob Meal	7	16.62	7.30	3.09	3.60	45.70	7	....	....	....	....	....	....
Corn and Oats	18	10.98	11.03	4.72	3.23	69.27	15	....	....	3	3	....	....
Corn Gluten Feed	11	8.36	23.81	2.20	6.16	74.40	8	2	1	....	3	....	....
Corn Gluten Meal	1	9.95	35.25	2.34	0.95	......	......	1	....	....	1	....	....
Corn Oil Cake Meal	1	5.71	24.06	7.22	8.72	......	1	....	....	....	....	....	....
Distillers' Dried Grains—Yeast	3	5.36	20.72	6.87	17.62	54.50	3	....	....	....	....	....	....
Dried Beet Pulp	3	9.93	8.34	0.86	19.16	58.33	3	....	....	....	....	....	....
Feed Mixtures	219	......	......	......	......	67.25	183	16	18	11	27	9	....
Feed Mixtures (N. J. Manufacturers)	68	......	......	......	......	62.60	45	4	7	15	20	3	....
Hominy Feed	10	9.08	11.24	7.17	3.26	67.30	9	....	1	....	1	....	....
Linseed Oil Meal	10	8.50	32.63	6.25	8.02	83.45	5	5	....	....	5	....	....
Malt Sprouts	3	8.43	26.59	1.05	11.62	62.67	1	....	....	....	....	....	....

Table 11—Continued
Summary of the Results of the Inspection

FEEDING STUFF	Number of Samples Examined	Average Composition: Moisture	Average Composition: Protein	Average Composition: Fat	Average Composition: Fiber	Average Retail Selling Price Per Ton	Number of Samples that Satisfied Guarantees	Number of Samples Deficient in—: Protein	Fat	Fiber	One Nutrient	Two Nutrients	Three Nutrients
ls	3	6.75	5.48	1.85	26.92	38.25	3	....	....	....	....	....	....
Bone	2	6.20	25.38	3.08	[3]	83.00	1	1	....	....	1	....	....
Feed	90	......	......	......	......	83.90	85	....	3	2	5	....	....
Feed (N. J. Manufacturers)	121	......	......	......	......	80.20	91	14	12	9	26	3	1
Meat	20	6.15	50.26	13.45	[4]	105.80	18	2	....	....	2	....	....
n	8	10.50	14.62	2.76	4.57	49.90	4	....	2	3	3	1	....
d	1	11.05	14.69	3.25	3.23	69.00	1	....	....	....	....	....	....
ldlings	12	11.16	13.80	2.80	3.16	59.80	8	1	1	4	3	....	1
Bran	65	9.09	14.93	4.48	9.48	52.14	53	2	....	11	11	1	....
Feed	6	9.49	16.16	4.75	7.11	58.40	5	....	....	1	1	....	....
eeding Flour	10	9.54	16.61	4.07	2.73	75.60	8	1	2	....	1	1	....
iddlings	65	10.25	16.08	4.78	5.70	65.75	48	2	7	10	15	2	....
nd Rye Middlings	1	10.63	16.13	4.53	4.86	64.00	1	....	....	....	....	....	....

sample not guaranteed.
o samples not guaranteed.
[3] sphoric acid 24.06%.
[4] sphoric acid 9.03%.

prices of several of the more important feeding stuffs as they were obtained during the last five inspections. These figures show that on the average the cost of feeding stuffs increased 15 per cent since the previous inspection and that the average increase since the 1916 inspection has been about 108 per cent.

These figures do not give any information that is new to the purchaser of feeds but it should make him realize the importance of securing materials that fully satisfy the guarantees given, since every pound of protein and fat that is guaranteed hut is not in the material when delivered, costs him at the rate shown in the tabulation.

Table 11 is a summary of the inspection. It shows the average composition of the various materials examined with the exception of calf meals, feed mixtures and poultry foods. The reason the averages are not given for these classes of feed is that the brands have such a variation in composition, an average of the results would not have any particular value. The table also includes the average selling prices and deficiencies.

In preparing this tabulation the protein content as found is considered substantially to satisfy the guarantee if it is not more than 1 per cent below it. An allowance of 0.5 per cent also is made for the fat and fiber content.

REPORT OF THE DEPARTMENT OF HORTICULTURE

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*Appointed September 1, 1920.
†Appointed March 1, 1920.
‡Resigned February 29, 1920.
§Resigned October 15, 1919.
**Appointed January 1, 1920.

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Report of the Department of Horticulture

Arthur J. Farley

During the year July 1, 1919, to June 30, 1920, the work of the horticultural department has been along the same lines as in former years. Lack of funds has prevented the starting of any important new projects, practically all of the time available for experimental work being devoted to the major projects started in former years, with only a few new projects of minor importance.

The work at Vineland was continued throughout the growing season of 1919, another excellent crop of peaches being harvested. In view of the fact that the experimental work was practically completed, it was decided that the Experiment Station was no longer justified in assuming responsibility for the active management of the orchard and, therefore, it was turned over to the Training School at Vineland on January 1, 1920. This transfer included the trees planted in 1907, 1908 and 1912. Certain phases of the pruning work will be continned at Vineland for a year or two, but otherwise the experimental work there will be discontinued, thereby opening the way for the development of more work at New Brunswick. It is impossible to measure the effect of the Vineland orchard upon the peach industry in New Jersey, but the results of the work there have been very striking, and of great value. Although the experimental work is practically completed, it will require several years to work up the mass of data secured and publish the results. With the Vineland project discontinued, the peach-breeding work at New Brunswick, under the direction of C. H. Connors, becomes the major fruit project. This work, started in 1914, will soon reach the point where it will be of direct value to the peach growers of the state, through the introduction of improved varieties. The fruits from about 650 seedling trees were studied and described by Mr. Connors, during the past year, a large majority being the result of definite crosses with both parents known.

Among the seedlings described this year, 66 were considered worthy of further trial, and a few trees of each have been propagated. A large number of crosses were made during the spring of 1920, 6 entire trees being covered with tents and 53 trees having 1, 2 or 3 twigs covered with parchment paper bags. The chief objects of this work are (1) to improve existing varieties; (2) to select promising seedlings and improve them, and (3) to study the inheritance of unit characters.

The apple-pruning experiment at New Brunswick has been continued as outlined, with the exception that the two plots involving summer pruning have been discarded because it was clearly shown that summer pruning of the apple is not practicable under New Jersey conditions, except as a corrective measure in shaping young trees. All varieties produced some fruit, Stayman having the heaviest crop, with Delicious, Rome, Wealthy and Baldwin following in the order named. In every case the unpruned trees produced the largest number of apples, with the winter-pruned but not cut-back second, and the winter-pruned and cut-back third. Many interesting facts of value to fruit growers have been brought out by these experiments and it is hoped that funds will be available during the coming year to publish the results of the apple-pruning work to date.

Several experiments of secondary importance have been started during the year, involving the fertilization of peaches and apples. The effect of potash on peaches is being studied, as well as the effect of early and late applications of acid phosphate and nitrate of soda on apples. It is too early to expect results from this work, and therefore no report will be made at this time.

Measurements to determine the rate of growth of apples are being taken for the third season, and a report on the work will be made next year.

The work in vegetable gardening has progressed rapidly during the past year, special emphasis being placed upon the fertilizer experiments with tomatoes. This vegetable work is being carried on by Prof. L. G. Schermerhorn, and his report will be found on pages 85 to 90.

The work in floriculture, under the direction of C. H. Connors and H. M. Biekart, has been continued on a limited scale; the work in carnation breeding occupying most of the time.

Staff Changes

As nsual a number of changes in the staff occurred during the year. Robert P. Armstrong, a graduate of the Massachusetts Agricultural College in 1910, was appointed assistant professor of horticulture in the College and assistant horticulturist in the Experiment Station on August 1, 1919. Henry B. Seaver was appointed instructor in horticulture on September 1, 1919, and devotes a part of his time to experimental work. Charles H. Cane resigned as orchard foreman on October 1, 1919, and Clarence H. Steelman, a graduate of the Short Course in Fruit Growing and Market Gardening, was appointed to take his place on January 1, 1920. William F. McIntyre resigned as assistant fruit specialist on November 1, 1919, to take up private work, and his place was taken on April 1, 1920, by Joseph R. French, a member of the class of 1915 of Rutgers College. T. M. Morgan resigned on November 1, 1919, as field assistant, and his place was filled on April 1, 1920, by the appointment of Louis M. Brooks. J. Vincent Breazeale resigned as vegetable foreman on February 1, and

H. Gordon Bailey was appointed on March 1 to take his place. Eugene E. Beyer resigned April 1, 1920, to go into commercial work, and his place was taken on May 1, 1920, by Fred W. Jackson, a graduate of Rutgers College in the class of 1920.

FRUIT-CROP CONDITIONS

The spring and summer of 1919 will go on record as a season of very heavy rainfall. Many crops were made practically worthless by the excessive rainfall, while others were of inferior quality. Scab on apples and brown rot an peaches was very prevalent, and reduced the crop by many bushels. A heavy crop of peaches was harvested in the central and southern part of the state in spite of the brown rot. The fruit as a rule was of inferior quality because of the excessive amount of rainfall.

The apple crop was up to the average in quantity, but somewhat below the average in quality on account of the large amount of scab and sooty fungus. Fire blight was prevalent in the central part of the state, but not at all serious in the southern and northern sections.

Pears were below normal in 1919, and the prospects for the 1920 crop indicate a smaller crop than in 1919 in spite of the heavy bloom. Weather conditions at blooming time, as a rule, were unfavorable for the setting of fruit. The number of bees was smaller than usual, while weather conditions were not at all favorable for their work in the orchards.

The strawberry crop in 1920 was somewhat larger than the previous year, as a result of an increased acreage. Red raspberries were very light, many of the canes being killed back to the ground during the severe winter of 1919-20.

PEACH BREEDING

Chas. H. Connors

Peach-breeding work on a large and systematic scale was begun at this Station in 1914, the progress of which has been noted in previous reports.

The first crop of peaches was harvested from the seedling trees during the summer of 1919, and very interesting results from both the economic and scientific sides were obtained. The fruits from about 650 seedling trees were studied and described, 546 of these being seedlings from known parents on both sides and the remainder open-pollinated seedlings of Late Crawford, Early Crawford and St. John. Some were from a tree of Early Crawford that had been covered and crossed with Greensboro, Belle and Elberta, but the fruits from the crossed tree were all picked in one basket. This means that from the scientific side the material is lost, but, from the economic side, anything good coming from these seedlings would be just as valuable as

No definite record was preserved of the yield. Considerable variation was found among the trees of the various crosses, but a noticeable superiority was seen among those seedlings resulting from the crossing of white varieties or white and yellow. Belle X Greensboro, for example, gave some trees that yielded 1½ baskets during the third summer in the life of the tree in the orchard.

All of these fruits were classed arbitrarily, the basis being "desirable," in this class, all trees being listed whose fruit was of sufficient merit to be planted commercially, but not necessarily superior to the present commercial varieties and therefore worthy of propagation and dissemination among the growers. The other classes were "may be desirable," "not very desirable," and "not desirable." In the last class were placed most of the clingstones, those markedly poor in quality, small in size, of small yield and noticeably susceptible to brown rot.

Of the 546 seedlings from known parents, 155, or 28.3 per cent, were "*desirable*;" 156, or 28.7 per cent, were classed "may be desirable;" 80, or 14.7 per cent, were "not very desirable;" and 155, or 28.3 per cent, were "not desirable." The fruit was sold locally and all of the fruit from the first three classes and part of the "not desirable" class were salable. In all, the fruit from about 75 per cent of the trees could be sold on a local market. There are no records of other large peach breeding experiments, but we have some reports of seedlings from the promiscuous sowing of seeds, and in the latter case only a small percentage of the seedlings yield marketable fruit. That seedlings from the breeding of parents of known quality should be superior to "mongrel" seedlings is obvious from these figures.

The improvement of present varieties of peaches and the extending of the season for certain classes, such as yellow-fleshed and freestone kinds, is one of the objects of these experiments. Of course, a test of only one year is not sufficient basis for the dissemination of a new variety. However, 66 of the seedlings were considered worthy of trial and a few trees of each were propagated for further study. Not all of these will be of sufficient merit to replace older varieties. Probably some were passed over that should have been propagated, which might easily happen, as on some days as high as fifty or sixty seedlings were described.

Among those that appear most promising are the following:

1. Several seedlings of Belle X Greensboro, some semi-free and some freestones, ripening at or about the season of Carman, oval in shape, of very bright color, resistant to brown rot, vigorous in growth and productive, with good shipping and keeping qualities.
2. A seedling of Belle X Early Crawford, white in flesh, freestone, bright color, vigorous in growth, ripening at the time of Champion and having a flavor very similar to that variety, but resistant to brown rot.
3. Several seedlings of Belle X Early Crawford and Early Crawford X Belle that resemble Belle in shape but having the yellow flesh color of Early Crawford, of good quality, and ripening at the season of Belle.
4. A seedling of Early Crawford X Elberta, resembling Elberta in shape and color but of superior dessert quality, ripening about one week earlier than

Ripening Dates

The ripening dates of the various varieties concerned in this discussion were as follows, the date being that of the first picking:

Early Wheeler, July 17; Greensboro, July 27; Carman, August 8; Early Crawford, August 20; Belle, August 27; Elberta, September 4; St. John did not ripen fruit this season, but the date for this variety would have been about August 14.

Belle S. P. The first of 95 seedlings to fruit ripened on August 13 and the last one on September 16. The largest group, 38, ripened approximately with Belle, between August 25 and 29. Another group of 19 ripened from August 16 to 18 and a group of 15 from August 31 to September 2. None ripened after September 8 until the last one on September 16.

If Belle is a seedling of Chinese Cling X Early Crawford, the early ripening group would be explained, although it is a few days earlier than Early Crawford. The late-ripening group practically coincides with the ripening date of Chinese Cling.

Elberta S. P. Only 38 seedlings from this parentage fruited. The first one ripened on August 11 and the last on September 8. The majority ripened from August 31 to September 4. This would bring the greatest number to ripeness at the Elberta season.

Early Crawford S. P. The seedlings of this parentage were planted in 1917, so were in their third season, and only 6 bore fruit. These were scattered over the period from August 11 to 31, and are not sufficient in number to give any indication of how the date of ripening is inherited.

Belle X Elberta. The first to ripen in this lot were picked on August 22. A well defined group was picked between August 25 and 29, and another group between September 1 and 7. Twenty-one fruited at approximately the Belle season and 33 at approximately the Elberta season, which seem to indicate a slight prepotence of Elberta with respect to this character.

Elberta X Belle. The first of this group to ripen matured its fruit on August 22 and the last on September 9. The majority (33 out of 36) matured between August 28 and September 3, beginning about with Belle and lapping over into the Elberta season. Almost all ripened within the limits of the two varieties, which themselves overlap.

Belle X Early Crawford. Sixty-five seedlings from this cross fruited. The first ripened on August 8 and the last on September 6. There are four groups with the limits and numbers as follows: August 15 to 18, 18; August 21 to 25, 18; August 28 to September 2, 25; September 4 to 6, 4. The first group corresponds with Early Crawford; the third group about with Belle. The second group is an intermediate and the last group reflects the ripening date of Chinese Cling, parent of Belle, and also of Late Crawford, parent of Early Crawford.

Early Crawford X Belle. Only 8 of this cross fruited this season, extending from August 12 to September 2. The indications are that the results with respect to this character will be approximately the same as in the reciprocal of the cross.

Elberta X Early Crawford. Thirty-one seedlings of this group fruited, ripening from August 18 to September 7. The majority (25) ripened August 30 to September 2, just a little before Elberta. One ripened from August 18, about the Early Crawford season, and 5 from September 5 to 7, about the season of Late Crawford and Chinese Cling.

Early Crawford X Elberta. These 22 seedlings began to ripen on August 27 and the last one ripened on September 3, with the majority between August 29 to September 1. This is approximately the same as in the reciprocal.

Belle X Greensboro. This group comprised 113 seedlings. Only one, rip ing on July 21, approached the ripening date of the pollen parent, 68 ripened the period between August 7 and 12, which approximates the Carman sea and is about midway between the season of the parents. From July 30 August 6, 18 ripened and from August 13 to 18, 25 matured. One matured August 30. This seems to indicate a compromise, with the influence apparen slightly in favor of Greensboro. Now Greensboro is believed to be a seedl of Connets, which ripens at the same time with Carman.

Elberta X Greensboro. This group of 34 commenced to fruit on August the last one ripening on September 1. There is one group of 10 trees ripen in the period from August 2 to 7, another group of 22 in the group ripen between August 11 and 17, one tree which ripened on August 28 and one September 1. The number of individuals is smaller than in the case of B X Greensboro, but the tendency with respect to the date of ripening seems be about the same.

Early Crawford X Greensboro. Only 6 from this cross fruited, the dates ripening extending from August 11 to 31. The number of individuals is small to permit the drawing of any conclusions.

St. John X Early Wheeler. Twenty from this cross ripened. The earli was July 18 and the last August 7. These extend from about the Early Whee season not quite to the season of St. John, showing the strength of Ea Wheeler in the direction of setting forward the date of ripening.

St. John X Greensboro. Only 7 of these fruited, the first on July 25, season of Greensboro, and the last on August 1, about half-way between Gree boro and St. John.

It is evident from the foregoing statements that where such re tively pure varieties are bred, we do not obtain the great extremes periods of ripening obtained from promiscuous crossing or sowi open-pollinated seeds of some varieties. The tendency seems to mainly to attain the ripening periods of the parents, with a few a parently atavistic individuals. Future generations, however, may u set these results.

Inheritance of Color of Flesh

All of our commercial varieties of peaches are of unknown pare tage; of some, the seed parent is known. Elberta and Belle a seedlings of Chinese Cling, Greensboro is a seedling of Connets, a Early Crawford is a seedling of Late Crawford. Other than this information is available, although it is believed, and there is a po sibility, that the pollen or male parent of Elberta was Early Cra ford, and of Belle, Oldmixon. This, however, is mere conjecture.

It is of interest to learn just how these varieties behave in co tributing color of flesh to their progeny. So far, the results of the experiments seem to indicate that white is a dominant character a yellow is a recessive character, as related to color of flesh. A do inant character is one that is expressed unchanged, while a recessi character is one that becomes latent or masked by the dominan For example, if white is dominant, then in a cross between genetically pure white-fleshed peach and a genetically pure yello fleshed peach, all of the seedlings of the first generation should ha white flesh. This happened in the case of the seedlings resultin from crossing St. John with Greensboro, St. John with Ear

Wheeler, and Early Crawford with Greensboro, indicating that these four varieties are pure, or nearly so, for flesh color.

In the case of the peach, we have two kinds of white flesh, speaking from a breeding standpoint. The one kind is known as homozygous, which means that all of the seedlings from such a variety, self-pollinated, would be white-fleshed. The other is known as heterozygous, which means that it is of mixed blood, or if seedlings are secured from such a variety, self-pollinated, a certain proportion of them will be white-fleshed and a certain proportion yellow-fleshed.

There is no evidence apparent in the fruit of this mixed blood. It is shown, however, in the color of the inside of the calyx cup of the blossom. Those varieties that are yellow-fleshed are colored orange in the calyx cup; those that are white are greenish, creamy or buff. The evidence seems to indicate that pure white varieties have greenish or creamy calyx cups, while those that are of mixed blood are buff-yellow or orange-buff. The evidence to substantiate this is not quite complete. However, Greensboro and Early Wheeler, which have greenish calyx cups, behave like pure or homozygous whites, and Belle, which has a buff-colored calyx cup, behaves like mixed or heterozygous white, which would indicate some grounds for the statement.

Experiments show that Belle self-pollinated gives about 25 per cent of yellow-fleshed seedlings. When Belle is crossed with Elberta and Elberta with Belle, the resulting seedlings are about one-half white-fleshed and one-half yellow-fleshed. When Elberta is crossed with Early Crawford and Early Crawford is crossed with Elberta all of the seedlings will probably be yellow. As previously noted, Early Crawford X Greensboro, St. John X Early Wheeler and St. John X Greensboro gave or will probably give all white-fleshed seedlings. All of these seem to be heterozygous, so seedlings saved from them will split, some being white and some yellow of flesh.

The indications are that white is dominant over yellow, though dominance may not be complete. Furthermore, whenever a yellow variety is crossed with a white variety, the resulting seedlings are notably more vigorous.

Adhesion of Flesh to Stone

In these crosses, only freestones and clingstones were used. There is a difference in the adhesion of flesh to stone between Early Wheeler and Greensboro, the former being very clingy and the latter less so, but not enough to be classed as a semi-cling under the climatic conditions in New Jersey.

Table 1

Inheritance of Color of Fruit in the F-1 Generation

Number and Per Cent of White and Yellow

CROSS	FRUITED				NOT FRUITED				TOTAL			
	White		Yellow		White		Yellow		White		Yellow	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
elle S. P.	60	69.5	29	30.5	109	77.8	31	22.2	175	74.5	60	25.5
lberta S. P.	0	....	38	100.0	...	....	99	100.0	...	....	137	100.0
elle x Elberta	31	58.4	22	41.6	5	33.3	10	66.7	36	52.9	32	47.1
lberta x Belle	16	44.4	20	55.6	24	40.7	35	59.3	40	42.1	55	57.9
elle x Early Crawford	27	41.5	38	58.5	22	37.9	36	62.1	49	39.9	74	60.1
arly Crawford x Belle	5	66.5	3	37.5	10	50.0	10	50.0	15	53.6	13	46.4
lberta x Early Crawford	0	....	25	100.0	0	....	40	100.0	0	....	65	100.0
arly Crawford x Elberta	0	....	22	100.0	...	....	20	100.0	0	....	42	100.0
elle x Greensboro	113	100.0	0	.....	123	95.4	6	4.6	236	97.5	6	2.5
lberta x Greensboro	33	97.2	1	2.8	74	89.2	9	10.8	107	91.4	10	8.6
arly Crawford x Greensboro	16	100.0	0	.....	23	100.0	0	....	39	100.0	0	....
arly Crawford S. P.	0	....	5	100.0	0	....	55	100.0	...	....	60	100.0
t. John x Early Wheeler	20	100.0	0	.....	27	100.0	0	....	47	100.0	0	....
t. John x Greensboro	7	100.0	0	.....	17	100.0	0	....	24	100.0	0	....

The relation of the semi-clingstones is not clear. They seem to be order-line cases in that under varying climatic or weather conditions ley sometimes become cling and at other times almost free.

Where freestones are self-pollinated or crossed with other freeones, as shown in table 2, a large proportion of the seedlings, varyig from a little more than 50 per cent in the case of Early Crawford Elberta to 100 per cent in the case of Early Crawford self-polnated, are freestones. Only a few of the Early Crawford selfollinated seedlings ripened, so that the data for this variety are not

Table 2

Adhesion of Flesh to Stone

		FREESTONE		SEMI-CLING		CLINGSTONE	
	Total	Number	Per cent	Number	Per cent	Number	Per cent
elle S. P.	95	61	64.3	14	14.7	20	21.0
lberta S. P.	41	29	70.8	1	2.4	11	26.8
elle x Elberta	53	34	64.2	3	5.6	16	30.2
lberta x Belle	36	25	69.5	5	13.9	6	16.6
elle x Early Crawford	65	52	80.0	1	1.5	12	18.5
arly Crawford x Belle	8	6	75.0	0	....	2	25.0
lberta x Early Crawford	31	21	67.8	1	3.2	9	29.0
arly Crawford x Elberta	22	12	54.5	2	9.1	8	36.4
elle x Greensboro	113	37	32.7	50	44.3	26	23.0
lberta x Greensboro	34	14	41.2	10	29.4	10	29.4
arly Crawford x Greensboro ..	16	5	31.2	4	25.0	7	43.8
arly Crawford S. P.	6	6	100.0	0	....	0	....
. John x Early Wheeler	20	0	....	3	15.0	17	85.0
. John x Greensboro	7	2	28.6	0	....	5	71.4

onclusive. However, in the Belle X Early Crawford cross and the eciprocal, Elberta X Early Crawford, from 67.8 to 80 per cent of the eedlings were freestones. Both Belle and Elberta seem to carry a actor for clinginess of about one-third, as about two-thirds of the eedlings are freestones.

When freestones are crossed with clingstones, a higher proportion f clingstones is secured. Elberta X Greensboro, however, gives a rger percentage of freestones than does Belle X Greensboro. This ight be expected, judging from the behavior of Elberta and Belle hen self-pollinated, Elberta S. P. giving a slightly greater per cent f freestones than Belle S. P.

The effect of the difference in relative clinginess of Early Wheele and Greensboro is shown in the seedlings. St. John X Early Wheele gave no freestones, while St. John X Greensboro gave 28.6 per cer free. The population in the latter case is very small.

Further crosses have been made in an effort to ascertain the relatioı ship of the semi-cling group, and also of the clingstone group. Or point was made very clear in the series under discussion, and th is that it is impossible to secure viable seeds from the early-seaso clingstone varieties.

Freestone X freestone gave about two-thirds freestone seedlings an one-third either semi-cling or cling.

Freestone X clingstone gave a large proportion of clingstone seec lings, varying with the degree of clinginess of the parents and wit the power of the freestone parent to produce freestone seedlings.

Bloom in the Spring of 1920

The blooming period in the spring of 1920 was 16 days later i starting than in 1919, beginning April 8, 1919, but not until Apri 24, 1920. The trees, of course, were one year older, so that a large volume of bloom was shown and a longer period ensued between th first bloom and full bloom. Although the bloom started later thi year, the weather was, if anything, less favorable than last year, s that while some trees had their first bloom on April 25, the last ha their first bloom on May 9, a period of 16 days, as compared with 1 days in 1919. Rain fell on 16 days out of the 28, during which th trees were in bloom and more than half of the days were cloudy o partly cloudy. The temperatures were fairly uniform, there bein one light frost and one heavy frost during the blooming period, th maximum temperature heing 79 and the minimum 36.

The largest number of seedlings bloomed first within the perio from April 25 to 29. This corresponds with the blooming dates o the majority of the commercial varieties. This fact held true als for the bloom in 1919, but there were more that bloomed earlier i 1920 than in 1919. This is due to the fact that the trees are becomin mature. It has been found where very young trees have made a rapi growth, that the tendency is for such trees to bloom later than th average.

As was noted in the annual report for 1919, some of these tree were notably late in hlooming. A variety that blooms late ma escape late frosts. In a few of the cases, the late bloom was due t the growth of the trees the previous season. Some, however, bloome late this year, so the character seems to be fixed. Among these ar several Belle S. P., Belle X Elberta, and one Belle X Greensboro While the fruits from these were not particularly desirable the fixa- tion of the late-hlooming character is important, and these trees give a basis upon which to work.

Blooming Dates of Seedlings Planted in 1918

Since those seedlings that were planted in 1918 had finished only the second season's growth, the blooming dates could not be directly compared with those of the older plantings. Accordingly, the blooming dates of the seedlings of the various crosses made in 1916 and planted in the orchard in 1918, were also considered.

Table 3

Blooming Dates of Varieties of Peaches at New Brunswick, April and May, 1920

VARIETY	First	Full
Arp (Beauty)	5/4	5/11
Belle (of Georgia)	5/2	5/10
B. G. Pratt	4/30	5/6
Carman	4/29	5/6
Early Crawford	4/25	5/4
Early Wheeler	4/29	5/7
Elberta	4/29	5/5
Foster	4/29	5/4
Greensboro	4/29	5/6
Heath Cling	4/29	5/10
Hiley	5/2	5/10
Iron Mountain	5/1	5/12
Japan Dream	4/29	....
J. H. Hale	4/28	5/5
Krummel	5/2	5/10
Late Crawford	4/28	5/5
Lola	5/2	5/10
Pearson	4/29	5/6
St. John	4/30	5/6
Slappey	5/3	5/10

These began to bloom on April 24, with the last one having first bloom on May 9. There was one large group to bloom between April 24 and 28, then came a period of two days when a few bloomed. Following that for four days another large group had their first bloom.

This series of crosses was made with the idea of breeding early yellow varieties but the factors of hardiness in bud and delayed

blooming also were considerations. Results showed that Early Crawford bloomed early, Lola and Carman about mid-season and Arp and Slappey, late. Dewey is also a late bloomer.

The seedlings of Lola S. P. seemed to be mostly early-season bloomers, but several are mid-season and one, late, the latest of all. Early Crawford seems to influence most of its seedlings, in this case, toward earliness of bloom, while Dewey, Arp and Slappey seem to carry this factor for late blooming and to be able to transmit it to their progeny in some degree. The results for this season must not be considered final, however, as the trees have not yet matured.

Table 4

Number of Peach Seedlings Having First Bloom on Various Dates in April and May, 1920

	APRIL							MAY								
	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9
Belle S. P.	1	9	7	3	38	23	11	11	25	10	17	9	3	2	...	1
Elberta S. P.	2	40	12	8	26	16	...	...	2	5	1	1	...	...	1	...
Belle x Elberta	...	9	3	1	20	4	4	...	1	2	...	1	...	...	...	...
Elberta x Belle	...	27	5	1	21	10	2	...	3	1	...	...	...	...	1	...
Belle x Early Crawford	...	24	10	2	31	7	...	3	1	...	...	1	...	...	...	...
Early Crawford x Belle	...	2	2	2	13	4	2	...	...	...	...	...	...	...	...	...
Elberta x Early Crawford	...	28	...	6	13	10	...	...	1	2	...	...	...	...	...	...
Early Crawford x Elberta	...	11	1	2	11	...	...	...	...	1	1	...	...	...	...	...
Belle x Greensboro	1	50	20	6	49	4	1	2	...	1	1	...	...	...	...	...
Elberta x Greensboro	...	55	12	4	17	4	1	...	...	...	...	...	...	...	...	...
Early Crawford x Greensboro	...	20	3	1	3	...	...	...	...	...	...	...	...	...	...	...
Early Crawford S. P.	...	11	1	2	11	...	...	...	...	1	1	...	...	...	...	...
Total	4	286	76	38	253	82	21	16	33	23	21	12	3	2	2	1

Inheritance of Size of Blossom

In the annual report for 1919, it was brought out that the large and small blossoms seem to breed pure, while large blossoms crossed with small give all medium-sized blossoms. The seedlings and varieties bearing medium-sized blossoms when self-pollinated or crossed among each other gave seedlings that split up into practically the Mendelian ratio of 1 large—2 medium—1 small, showing that the large and small blossoms are homozygous for size while the medium-sized blossom is an intermediate and heterozygous.

Table 5

Blooming Dates of Peach Seedlings, Showing the Number Having First Bloom on Various Dates

	APRIL							MAY									
	24	25	26	27	28	29	30	1	2	3	4	5	6	7	Bloomed	No Bloom	Total
Lola S. P.	4	5	15	1	26	6	9	1	8	3	2	1	......	1	82	2	84
Lola x Arp	....	5	......	1	30	4	8	1	3	......	......	......	1	......	53	1	54
Lola x Early Crawford	....	13	......	2	28	2	3	4	9	7	2	......	1	......	71	0	71
Lola x Slappey	....	1	1	......	9	......	1	5	17	2	......	......	2	......	38	0	38
Carman S. P.	....	......	......	......	7	......	......	2	6	1	3	1	......	......	20	0	20
Carman x Slappey	....	......	......	......	......	......	......	1	2	1	......	......	......	......	4	0	4
Early Crawford S. P.	....	......	......	......	9	......	......	6	8	1	1	......	......	......	25	0	25
Early Crawford x Arp	....	......	......	......	5	......	......	2	2	......	......	......	......	......	9	0	9
Early Crawford x Dewey	....	......	......	......	2	......	......	......	2	......	......	1	......	......	5	0	5
Early Crawford x Slappey	....	1	......	......	13	......	......	3	10	2	1	......	......	......	30	0	30
Slappey S. P.	....	......	......	......	......	......	......	......	2	5	4	1	......	......	12	0	12
Slappey x Arp	....	......	......	......	3	......	......	3	16	6	3	......	......	......	31	0	31
Slappey x Early Crawford	....	......	......	......	3	......	......	......	2	1	......	......	......	......	6	0	6
Slappey x Dewey	....	1	......	......	11	......	......	4	11	7	4	2	......	......	40	0	40
Total	4	26	16	4	146	12	21	32	98	36	20	6	4	1	426	3	429

Table 6

Size of Blossom and Probable Color of Fruit of Peach Seedlings

	SIZE OF BLOSSOM						PROBABLE COLOR OF FRUIT				Size of Blossoms of Parents
	Large		Medium		Small		White		Yellow		
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
Lola S. P.	82	100.0	0	0	0	0	64	78.0	18	22.0	L X L
Lola x Arp	50	94.4	2	3.9	1	1.7	53	67.9	25	32.1	L X L
Lola x Early Crawford	2	2.8	69	97.2			38	53.5	33	46.5	L X S
Lola x Slappey			38	100.0			17	44.7	21	55.3	L X S
Carman S. P.	16	80.0	4	20.0			20	100.0			L X L
Carman x Slappey			4	100.0			4	100.0			L X S
Early Crawford S. P.					25	100.0	0		25	100.0	S X S
Early Crawford x Arp			9	100.0					9	100.0	S X L
Early Crawford x Dewey					5	100.0			5	100.0	S X S
Early Crawford x Slappey					30	100.0			30	100.0	S X S
Slappey S. P.					12	100.0			12	100.0	S X S
Slappey x Arp			31	100.0					31	100.0	S X L
Slappey x Early Crawford					6	100.0			6	100.0	S X S
Slappey x Dewey					40	100.0			40	100.0	S X S

Lola, Carman and Arp have large blossoms, while Early Crawford, Slappey and Dewey have small blossoms.

All of the Lola S. P. seedlings have large blossoms. The Lola X Arp and the Carman S. P. seedlings show a slight variation from the rule, but these may be due to error in pollination. All of the small-blossomed varieties when self-pollinated or crossed with other small-blossomed varieties gave seedlings bearing small blossoms. Large blossoms crossed with small gave all medium blossoms.

Color of Flesh of Seedlings Planted in 1918

Lola seems to be heterozygous, with a factor of about 25 per cent for yellow. When crossed with Arp, only one-third of the seedlings will be yellow, while when crossed with the other yellow varieties, about one-half will be white and one-half yellow. Unfortunately, Arp is one of the varieties that does not mature seeds so that its behavior with respect to flesh color is not known. Yellow being apparently the recessive color, a yellow variety should be homozygous, but there seems to be some question about this. However, when Arp is one of two yellow varieties crossed, it seems to behave like a true recessive. As has been previously stated, the size of the population plays a great part in working out these laws, so that when only a relatively few seedlings are obtained, the evidence is not always conclusive.

Carman behaves like a homozygous white, and, judging by the color of the calyx cup, seems to be homozygous.

Early Crawford, Slappey and Dewey behaved like homozygous yellows.

Set of Fruit

The fruit set seems to be uniformly good on most of the seedlings of the older plantings. There are a few that seem to be notably low yielders, and these will be culled out unless they happen to possess some character that requires further study.

On the young block, there was a good bloom on some trees and most had enough of a set so that some indication of quality could be had if the crop was carried through. However, a severe attack of plum curculio was experienced, and then a spell of wet weather at a critical period has forced a rapid growth of these trees so that in all probability a large part of the set will drop.

Conclusion

Altogether, the result of the first crop from part of the seedling trees is very encouraging. Such trees as gave no promise were removed from the orchard to give more room for the more promising

ones. Of the most promising, as was noted previously, a few trees were budded and these will be set out for further trial, as they may behave differently under another environment and on other stock. However, the results so far have encouraged us in the belief that we are adopting the right method and that in all probability we shall be able to add to the list of varieties some that will be of commercial importance.

Breeding Work in 1920

During the spring of 1920, further breeding was done, but the scope of the work was narrowed because of lack of funds. Six trees were covered with tents. These trees were as follows:

1. Belle S. P., large bloom, an oval yellow freestone peach quite similar to Belle, of good quality, ripening about a week before Belle.
2. Belle S. P., small blossom, late blooming, white freestone of good quality, medium size, shaped like Elberta and ripening about the season of Elberta.
3. Belle S. P., small-medium blossom, yellow, semi-free of good quality, oval shape, about Belle season.
4. Belle S. P., small-medium blossom, late blooming, yellow freestone of good quality and above medium in size at the season of Belle.
5. Belle S. P., large blossom, yellow freestone of good quality, Elberta in shape and a week earlier, bronzy color.
6. Belle X Greensboro, large blossom, white freestone of fair quality (good for season), Belle shape, a few days later than Carman.

These were crossed among each other and in addition on (1) and (3) part was crossed with Arp, on (5) and (6) part was crossed with Slappey, and on (6) part was crossed with Late Crawford for quality.

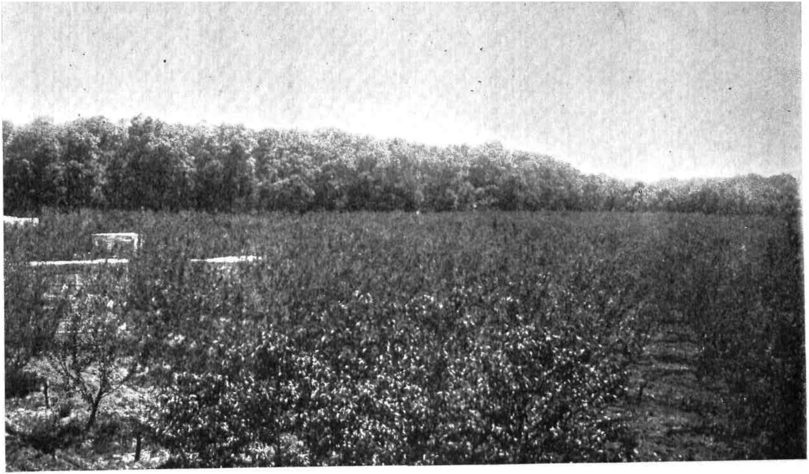
In addition to the above, 53 trees had one, two or three twigs covered with a special grade of parchment paper bags to secure a few self-pollinated seeds in order to get a further line on the inheritance of blossom size, color of flesh and adhesion of flesh to stone.

New Peach Planting

In the spring of 1920, the planting of a new peach orchard was begun on the Morrisey Farm, which has been leased for a period of years. This farm adjoins the horticultural farm and the new planting has been made in such a way that the rows are continuations of the standard apple orchard interplanted with peach seedlings that was set in 1916. The new peach planting consists of pruning plots and a variety test plot.

The pruning experiments are the outcome of the pruning experiments formerly conducted on the College Farm and at Vineland. Three points are under consideration, as follows:

1. To compare various types of winter and summer pruning. There are seven treatments in all, two check plots and three summer and three winter-



Section of Planting of Peach Seedlings Showing Some Desirable Ones Covered With Tents for Further Breeding

only; (b) thin twigs and cut remainder back 1 to 3 inches; (c) cut twigs 1 to 3 inches without thinning. The winter or dormant-season treatments are as follows: (a) thin twigs only; (b) thin twigs and cut back the remainder 1 to 6 inches; (c) cut back 1 to 6 inches without thinning. There are 10 trees to each plot, 5 of the variety Elberta and 5 of the variety Liberty.

2. To study the effect upon top growth of rubbing the suckers from the trunks of the trees during the first season in the orchard. There are two treatments: (a) suckers to be rubbed off when 1 to 2 inches long and kept rubbed off; (b) suckers are to be rubbed off when 6 inches to 18 inches long. There are 10 trees to each treatment, 5 Liberty and 5 Elberta.

3. To study the effect, upon the girth of the trunk and upon the height at which fruit is borne, of forming the head of peach trees at various heights from the ground. There are 10 trees in each treatment, 5 Elberta and 5 Liberty. These are to be headed between 6 and 12 inches, 18 and 24 inches, 30 and 36 inches and 42 and 48 inches.

The pruning treatment these are to receive later is a comparison between thinning only during the dormant season and thinning and cutting back during the dormant season.

The variety planting is an attempt to collect the most promising commercial varieties grown in this and other countries. It will include, also, some varieties that are of historical interest, that is, varieties that have been the foundation of our commercial varieties. There are to be included also many of the wild species of peaches that are imported from Eastern Asia.

Space will be available to test the new varieties arising from the breeding work here and also promising seedlings arising throughout the state, of which there are many.

Three trees of each of the following varieties of peaches, nectarines, almonds, and apricots were set this year.

Peaches—Arp, Belle, Carman, Connets, Crosby, Dewey, Early Crawford, Elberta, Fitzgerald, Foster, Greensboro, Heath Cling, Hiley, Hill's Chili, Ingold, Iron Mountain, Jeunie Worthen, J. H. Hale, Krummel, Liberty, Lola, Oldmixon, Orleans, St. John, Slappey, Stevens, Tennessee Everbearing, the double white-flowered and the double rose-flowered horticultural varieties.

The following varieties are from New Zealand, the introduction number being given as used by the Division of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, United States Department of Agriculture: Ice Cream (S.P.I. 43126), Ideal (S.P.I. 43127), Late Champion (S.P.I. 43129), Lippiatt's Late Red (S.P.I. 43130), Motion's Cling (S.P.I. 43132), Muir's Perfection (S.P.I. 43133), Osprey Improved (S.P.I. 43134). Paragon (S.P.I. 43135), Shipper's Cling (S.P.I. 43136), Up-to-date (S.P.I. 43137).

The following varieties from the Bureau of Plant Industry were also planted: Dwarf Chinese Peach (S.P.I. 40001), Sutter Creek (S.P.I. 43125), Fei peach from China (S.P.I. 38178), Vainqueur (from Spain) (S.P.I. 33219), Mexican peach (S.P.I. 32374).

Nectarines—The following nectarines introduced from New Zealand by the Bureau of Plant Industry were planted: Diamond Jubilee (S.P.I. 43140), Goldmine (S.P.I. 43141). Lippiatt's Late Orange (S.P.I. 43142), Muir's Seedling (S.P.I. 43143), New Boy (S.P.I. 43144), Sure Crop (S.P.I. 43146).

Almond—Del Desmayo, from Spain (S.P.I. 33218).

Apricot—From Turkestan (S.P.I. 17154).

It is planned, funds permitting, to add other varieties to this planting next year. This collection will be valuable for refereuce in the

breeding work with peaches, and also historically, as through it, may be possible to trace the probable parents of some of our coı mercial varieties that are used in the breeding work.

CARNATION BREEDING

The breeding work with carnations is proceeding slowly, and nc gives promise of early results.

Among the seedlings that bloomed this year were a number of ve vigorous plants that bore red flowers of good quality, although t color was not what is desired. However, several other very vigoro seedlings bore flowers of a very desirable color, but the quality was n desirable. The parent plants of these have been saved, so that ne year it is hoped that early bloom will be secured and a larger grou of seedlings will then be available for study the following season.

The wisdom of long testing of new varieties before disseminati has been confirmed again. as one of the purple varieties proves to not adaptable to varying conditions. Several of the other seedling notably a white striped with red (James Whitcomb Riley X Whi Perfection), a purple (Princess Dagmar X White Enchantress), purple variety with the petals edged with white (Princess Dagmar Matchless) are very promising.

This year the collection of species of Dianthus has been increase by the addition of fifteen, seeds of which were received from Englan too late, however, to secure much bloom this year. It is planned learn whether these species will cross among each other and with t greenhouse carnation, and what the result will be.

Pure line white, red and purple, the first two for three generatioı and the latter for two, have been secured for the study of color ii heritance.

Variation in Development of Carnation Buds at Different Seasons of the Year

Studies of the splitting of the calyxes of carnations have been mac at this station since the beginning of work in floriculture. The studies were systematized and made more thorough in 1915, and sinc that time have progressed slowly, reports of results having been pul lished in the annual reports for 1913 and 1916.

Incidental to the studies this year the seasonal variation of the ra of growth of the carnation buds was noted especially, and the fac are reported at this time.

The rate of growth of the buds is obtained by means of four mea urements: (a) the width between the tips of the upper bracts; (b the length of the calyx from the tip of the uppermost bract to th tips of the sepals; (c) the width between the tips of two opposit

Table 1

Growth of Carnation Flower Buds at Various Seasons 1919-20

Bud Number	1								2				3				4			
Measurement	a		b		c		d		a		b		a		b		a		b	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Start	....	3.00	....	1.00	....	......	....	......	....	6.50	....	3.50	....	5.50	....	3.50	....	6.00	....	3.50
First 7 days	0.50	5.25	1.50	4.50	....	......	....	......	0.25	3.00	0.25	3.25	1.00	3.25	0	3.00	1.50	3.50	1.25	3.00
Second 7 days	1.00	3.75	1.25	4.75	....	......	....	......	0.25	2.50	0.25	3.75	0.25	1.50	0	2.50	0.75	2.25	0.75	2.75
Third 7 days	0	1.00	0.50	3.00	....	(3.00)	....	(15.50)	0	2.50	0	3.25	0	2.00	0	2.50	0	2.50	0.75	2.75
Fourth 7 days	0	1.50	0.50	3.50	0	1.25	0	1.50	0	0.50	0	2.50	0.50	2.00	0.50	1.75	0	0	0	3.75
Fifth 7 days	0	0.50	0	2.00	0.25	12.00	0	2.00	0	0	0	3.25	0.25	1.00	0.50	1.50	0	0	0	1.00
Sixth 7 days	0	0	0	0	0	5.75	0	1.00	0	0	0	0.25	0	0	0	2.50	0	0	0	0
Seventh 7 days	Fully developed on 38th day.								0	0	0	0	0	0	0	1.75	....	....	....	....
													0	0	0	0.75				
									Fully developed on 44th day				Fully developed on 51st day				Fully developed on 36th day			

Bud 1 measurements began October 20, 1919.
Bud 2 measurements began November 3, 1919.
Bud 3 measurements began January 5, 1920.
Bud 4 measurements began March 24, 1920.

sepals; and (d) the maximum width of the calyx. The (c) measurement begins when the bud begins to show color and the (d) measurement at the same period. The measurements are made to the nearest 0.25 mm. and are taken daily at 8 A. M. and 5 P. M.

Table 1 shows the gain in growth by 7-day periods of four buds which began to develop at different times. These buds were normal. *All measurements are in millimeters. The line marked "start" shows* the size of the bud at the time measurements began. The figures in the columns indicate the actual gain in growth made by the bud during the period, and whether the gain was made during the day or during the night.

It will be noted that buds 2, 3 and 4 were practically uniform in size at the time measurements were begun, but that they were at least 4 *days farther than bud 1 was at the beginning. This should be added* to the period of development of the others.

In the first place, it will be noted that bud 1, maturing during October and November, required 38 days to reach its full development; bud 2, maturing in November and December, required 48 days, counting in the handicap over bud 1; bud 3, maturing in January and February, required 51 days plus 4 days, or a total of 55 days; bud 4, *maturing in March and April, required 36 days plus 4 days, or a* total of 40 days. Buds 1 and 4, then, required practically an equal period in which to develop fully. Light is one important factor in the development of the plant and of the flower, so that the intensity and duration of the sunlight would seem to be about equal during the development of buds 1 and 4, the periods being respectively October 20 to November 26, inclusive, and March 24 to April 28, inclusive.

Another fact that will be noted is that practically all of the gain in growth is made during the night. Normally, at the beginning of the measurements a small amount of growth is made during the day. This holds true with all four buds tabulated. Bud 3, (a) and (b) measurements, shows a gain during the day for the fourth and fifth week. This period extends from January 26 to February 7, during which time a majority of the days were cloudy or partly cloudy, and, *in addition, considerable snow fell, acting as a shade on the glass.* This was the period of the 1920 blizzard.

The bud swells during a period of about 14 days, at which time growth usually ceases so far as the (a) measurement is concerned. The (b) measurement, which is the length of the calyx from the tip of the uppermost bract to the tip of the calyx, continues to grow, very rapidly for the first 4 weeks, then practically ceases, for the flower *then begins to show color. It will be noted, however, that in* the case of (b) measurement, bud 3 continued to grow for almost the *entire period of development,* gradually slowing up at the end.

Just as soon as the petals break out from the calyx, which would be in fourth week for buds 1 and 4, the fifth week for bud 2 and the sixth week for bud 3, the (a) measurement begins to decrease. The growth of the petals inside of the calyx up to that time has evidently

stretched the calyx, but as soon as the blade of the petals has expanded above the calyx, the apparent elasticity of the calyx comes into play, allowing a shrinkage of the (a) measurement.

The conclusions to be dawn from these tables are: (1) that during the dull winter months, the flower bud requires from one to three weeks longer to develop than in the fall and spring months; (2) that the greatest part of the growth of the flower bud occurs during the night. The plant elaborates the food during the day and digests it during the night.

Former studies have shown that dull days are in part responsible for the splitting of the calyces of the carnations. Experiments to determine at what period the impulse of splitting is given, and what is the actual cause or causes are still under way, and considerable progress has been made. Plants have been grown under different degrees of shade and uuder varying conditions of heat and moisture, and a more intensive study of these conditions is planned for next year.

FERTILIZER EXPERIMENTS WITH TOMATOES IN 1919

L. G. Schermerhorn

Tomato growers in New Jersey are divided into two distinct classes: (a) those who grow for the general market, and (b) those who grow for the canneries. The work with fertilizers in 1919 was planned to meet the needs of both of these classes.

The object of the experiments was to study the effects of the different fertilizing elements and mixtures of these elements, sources of nitrogen, methods of applying the fertilizer and to bring out other important points that might form a basis for future work.

The experimental work relating to can-house tomatoes was carried out on the farm of N. B. Jones, at Masonville, in Burlington county, while that relating to the general market tomato was carried out on the horticultural farm at New Brunswick.

The soil at both places was well adapted to the growing of tomatoes. At Masonville the soil was a medium sandy loam, while at New Brunswick it was a sandy silt loam.

At Masonville the soil treatment during the 2 years preceding the tomatoes was as follows: 1917 potatoes, 1918 corn (clover and grass seeded in corn at the last cultivation). The use of the clover sod undoubtedly accounts in a measure for the results.

At New Brunswick the soil had been in alfalfa for 2 seasons, but was not in as high a state of cultivation as the soil at Masonville. There were 24 plots and their duplicates. At Masonville they were 1/36 acre iu extent on which 80 plants were set. At New Brunswick the plots were 1/50 acre in extent and 60 plants were set. The seed used was the writer's own selection of Bonny Best, and the plants were all grown at New Brunswick. The plants were transplanted into flats

once before being set in the field. When set in the field they were stocky, hardy, and had a large root system ready to go to work at once. The plants were set out May 15 in rows 5 feet apart, 3 feet apart in the rows. The rows were made up with a Darnell marker. When the furrows were marked out 400 pounds to the acre of fertilizer was applied in the row, and covered when the ridges were made up. This was done about 10 days previous to the time for setting in order that the fertilizer might become mixed with the soil, and not burn the roots of the plants when set out. The remaining portion of the fertilizer was applied after the rows were ready to have the plants set.

Plots 1 to 24 received an application of hydrated lime at the rate *of 1 ton per acre; plots 25 to 48 were unlimed.*

The fertilizers used were as follows:

Plot No.
1. *Check.*
2. 600 lbs. acid phosphate.
3. 800 lbs. acid phosphate.
4. 1000 lbs. acid phosphate.
5. 600 lbs. acid phosphate, plus 100 lbs. KC1.
6. 800 lbs. acid phosphate, plus 100 lbs. KC1.
7. 1000 lbs. acid phosphate, plus 100 lbs. KC1.
8. *Check.*
9. 600 lbs. acid phosphate, plus 200 lbs. KC1.
10. 800 lbs. acid phosphate, plus 200 lbs. KC1.
11. 1000 lbs. acid phosphate, plus 200 lbs. KC1.
12. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 100 lbs. $NaNo_3$.
13. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 200 lbs. $NaNo_3$.
14. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 150 lbs. $NaNo_3$, plus 37½ lbs. $(NH_4)_2SO_4$
15. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 100 lbs. $NaNo_3$, plus 75 lbs. $(NH_4)_2SO_4$.
16. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 150 lbs. $(NH_4)_2SO_4$.
17. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 150 lbs. $NaNo_3$, plus 100 lbs. fish.
18. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 100 lbs. $NaNo_3$, plus 200 lbs. fish.
19. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 50 lbs. $NaNo_3$, plus 300 lbs. fish.
20. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 400 lbs. fish.
21. *Check.*
22. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 100 lbs. $NaNo_3$, plus 37½ lbs. $(NH_4)_2SO_4$ and 100 lbs. fish.
23. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 200 lbs. $NaNo_3$.
24. 800 lbs. acid phosphate, plus 200 lbs. KC1, plus 200 lbs. $NaNo_3$.

Plot 13 is the standard mixture, of the analysis 2.5-10-8, upon which the sources of nitrogen were based. The sources of nitrogen substituted in varying amounts for the nitrate of soda were ground fish *and sulfate of ammonia.*

The 6 check plots at Masonville averaged a yield of 5.1 tons per acre. The 4 check plots at New Brunswick averaged 7.1 tons per acre.

The acid phosphate alone at Masonville did not increase the yield of ripe fruit materially, neither did the addition of 100 pounds of muriate of potash to the acid phosphate. When 200 pounds of muriate of potash was added to the acid phosphate a decided increase was obtained as may be seen by consulting table·1. When nitrogen was added to the acid phosphate and muriate of potash, a still greater increase was noted in most cases.

The highest yield on any one plot at Masonville was recorded on plot 12, which gave a yield of 10.9 tons per acre.

The average yield for plots 12 and 36 was 9.5 tons per acre.
The average yield for plots 19 and 43 was 9.6 tons per acre.
The average yield for plots 13 and 37 was 8.4 tons per acre.
The average yield for plots 20 and 44 was 8.4 tons per acre.

For the results on the other plots consult table 1.

At New Brunswick the results are similar to those obtained at Masonville with one or two exceptions.

The results with acid phosphate alone are more marked. The highest yielding individual plots at New Brunswick were plots 2 and 9. The highest two average yields are recorded on plot 2 and its duplicate 26, the average being 13.8 tons per acre and plot 9 and its duplicate 33, the average being 12.1 tons per acre.

The results which were similar to the Masonville results were recorded on plots 9, 10 and 11 which out-yielded plots 5, 6 and 7.

Plots 13 and 37 gave an average of 10.7 tons per acre.
Plots 12 and 36 gave an average of 11.2 tons per acre.
Plots 20 and 44 gave an average of 9.6 tons per acre.

Consult table 1 for other results.

The results obtained are interesting, but we should not draw our conclusions too hastily. It will be necessary to carry this work on for at least one more season before definite recommendations can be made.

Outline of Tomato Work in 1920

The experimental work with tomatoes is being continued in 1920 with additions and modifications made to fit the needs of the locality in which the work is being done. The experiments are being continued in Burlington county on the farm of N. B. Jones, at Masonville.

In Cumberland county a new project on can-house tomatoes has been started on the farm of the Sheppard Farms Company, at Cedarville.

Another new project has been started at New Brunswick on tomatoes, which parallels Dr. W. H. Martin's potato work.

Table 1
Results of Experiment on Fertilizing Tomatoes

Plot	Application of Fertilizer per Acre	Yields per Acre: Masonville, limed	Yields per Acre: Masonville, unlimed	Yields per Acre: College Farm, limed	Yields per Acre: College Farm, unlimed	Average Yield per Acre: Masonville	Average Yield per Acre: College Farm
		lbs.	lbs.	lbs.	lbs.	tons	tons
1	Check	9,938	11,583	19,219	.....	5.38	9.61
2	600 pounds acid phosphate	11,430	12,411	22,572	32,744	5.96	13.88
3	800 pounds acid phosphate	11,322	11,615	22,978	26,391	5.73	12.34
4	1000 pounds acid phosphate	11,495	10,910	25,304	25,447	5.60	12.69
5	600 pounds *acid phosphate* 100 pounds muriate of potash	17,442	14,176	18,285	25,327	7.90	10.90
6	800 pounds acid phosphate 100 pounds *muriate of potash*	10,825	10,595	18,822	26,219	5.36	11.26
7	1000 pounds acid phosphate 100 pounds muriate of potash	11,077	11,664	17,022	25,419	5.69	10.61
8	*Check*	7,551	10,053	12,050	14,822	4.40	6.72
9	600 pounds acid phosphate 200 pounds muriate of potash	13,118	16,598	21,168	31,915	7.43	13.27
10	800 pounds acid phosphate 200 pounds muriate of potash	18,077	15,165	24,338	27,744	8.31	13.02
11	1000 pounds acid phosphate 200 pounds muriate of potash	18,616	18,923	15,200	29,888	9.38	11.27
12	800 pounds acid phosphate 200 pounds muriate of potash 100 pounds sodium nitrite	21,814	16,261	21,544	24,394	9.52	11.48
13	800 pounds acid phosphate 200 pounds muriate of potash 200 pounds sodium nitrate	20,806	12,984	23,288	19,890	8.45	10.79
14	800 pounds acid phosphate 200 pounds muriate of potash 150 pounds sodium nitrate 37½ pounds ammonium sulfate	17,424	13,024	26,157	20,725	7.61	11.72
15	800 pounds acid phosphate 200 pounds muriate of potash 100 pounds sodium nitrate 75 pounds *ammonium sulfate*	17,944	13,590	27,478	24,847	7.88	13.08

Table 1.—Continued

Results of Experiment on Fertilizing Tomatoes

	APPLICATION OF FERTILIZER PER ACRE	Yields per Acre				Average Yield per Acre	
		Masonville		College Farm		Mason-ville	College Farm
		limed	unlimed	limed	unlimed		
Plot		lbs.	lbs.	lbs	lbs	tons	tons
16	800 pounds acid phosphate 200 pounds muriate of potash 150 pounds ammonium sulfate	15,239	12,134	28,547	21,207	6.84	12.44
17	800 pounds acid phosphate 200 pounds muriate of potash 150 pounds sodium nitrate 100 pounds fish	14,344	15,156	19,866	14,459	7.38	8.58
18	800 pounds acid phosphate 200 pounds muriate of potash 100 pounds sodium nitrate 200 pounds fish	17,111	15,282	24,325	16,160	8.10	10.12
19	800 pounds acid phosphate 200 pounds muriate of potash 50 pounds sodium nitrate 300 pounds fish	18,144.	20,475	29,079	16,125	9.65	11.30
20	800 pounds acid phosphate 200 pounds muriate of potash 400 pounds fish	20,776	18,351	22,210	16,500	9.78	9.68
21	Check	11,790	10,755	17,469	10,537	5.64	7.00
22	800 pounds acid phosphate 200 pounds muriate of potash 37½ pounds ammonium sulfate 100 pounds fish	16,913	13,910	21,615	15,476	7.71	9.27
23	800 pounds acid phosphate 200 pounds muriate of potash 200 pounds sodium nitrate	14,544	14,393	12,897	14,872	7.23	6.94
24	800 pounds acid phosphate 200 pounds muriate of potash 200 pounds sodium nitrate	14,486	14,544	......	......	7.26	....

Table 2
Experiment With Tomato Varieties Conducted on the College Farm

No.	VARIETY	SOURCE	Wgt. per fruit to Aug. 19	Total Weight to Sept. 9		Yield per plant		Yield per acre: 2,904 plants per acre planted 3 by 5 feet	
			oz.	lbs.	oz.	lbs.	oz.	lbs.	tons
1	Extra Early Wealthy	J. Bolgiano & Son	4.02	64	8	6	7.2	18,731	9.35
2	Landreth	D. Landreth Seed Co.	5.53	67	14	6	12.6	19,711	9.85
3	Prosperity	J. Bolgiano & Son	4.44	67	2	6	11.4	19,493	9.75
4	John Baer	J. Bolgiano & Son	2.81	49	8	4	15.2	14,375	7.2
5	New Glory	J. Bolgiano & Son	5.93	43	5	4	5.3	12,578	6.28
6	Early Detroit	D. Landreth Seed Co.	3.[illegible]9	35	8	3	8.8	10,309	5.15
7	Landreth Ten Ton	D. Landreth Seed Co.	1.38	52	9	5	4.1	15,264	7.65
8	Ponderosa	W. A. Burpee Co.	10.25	58	12	5	13.7	17,007	8.5
9	Brimmer	Woods, Stubbs & Co.	7.33	30	9	3	0.9	8,875	4.45
10	W. W. Tracy		4.56	57	1	5	11.3	16,571	8.27
11	John Baer	Alexander Forbes Co.	3.88	100	7	10	0.7	29,167	14.6
12	Atlantic Prize	Wm. Ewing & Co., Ltd.	4.40	83	11	8	5.9	24,303	12.15
13	Greater Baltimore	J. Bolgiano & Son	5.00	54	8	5	7.2	15,827	7.9
14	Florida Special	J. Bolgiano & Son	6.70	63	7	6	5.5	18,122	9.2
15	New Globe Crown Picked	D. Landreth Seed Co.	4.47	56	4	5	10.0	16,335	8.17
16	Golden Queen	W. A. Burpee Co.	5.00	51	12	5	2.8	15,028	7.5
17	Delaware Beauty	D. Landreth Seed Co.	4.89	16	15	1	11.1	4,919	2.46
18	Manyfold	Beckert's Seed Store	3.49	37	7	3	11.9	10,872	5.44
19	Golden Dwarf Champion	W. A. Burpee Co.	3.81	33	7	3	5.5	9,710	4.36
20	Isbell's New Early Bell	S. M. Isbell & Co.	6.07	92	15	9	4.7	26,989	13.49
21	The Bloomsdale	D. Landreth Seed Co.	5.72	64	6	6	7.0	18,695	9.35
22	Blue Ribbon Special	Wood, Stubbs & Co., Inc.	5.57	38	6	3	13.4	11,144	5.57
23	Early Detroit	J. Bolgiano & Son	4.29	45	8	4	8.8	13,213	6.61
24	Bonny Best	Campbell Soup Co.	5.58	43	7	4	5.5	12,614	6.31
25	New Extra Early Earliana	J. Harris Co.	4.99	100	4	10	0.4	29,113	14.55
26	Burpee's Sunnybrook Earliana	W. A. Burpee Co.	5.37	94	9	9	7.3	27,461	13.73
27	Baltimore Baer	J. Bolgiano & Son	4.44	24	11	2	7.5	7,182	3.59
28	Fordhook First Tomato	W. A. Burpee Co.	5.00	14	6	1	7.0	4,174	2.08
29	Puget Sound Special	Charles H. Lilly Co.	5.19	47	0	4	11.2	11,299	5.65
30	*Cupid*	Halstead—N. J. Agr. Exp. Sta.	3.83	9	12	0	15.6	2,831	1.42
31	Blue Ribbon Pioneer	Wood, Stubbs & Co.	5.19	55	15	5	9.5	16,239	8.12
32	Alacrity	Wm. Ewing & Co., Ltd.	5.22	28	15	2	14.3	8,403	4.2
33	Greater Baltimore	Campbell Soup Co.	5.78	37	11	3	12.3	10,944	5.47
34	New Century	J. Bolgiano & Son	4.66	54	9	5	7.3	15,845	7.92

PLATE 2

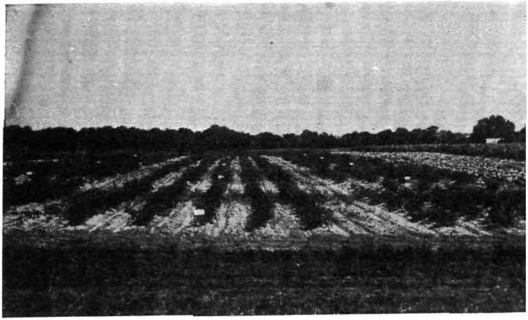


Fig. 1

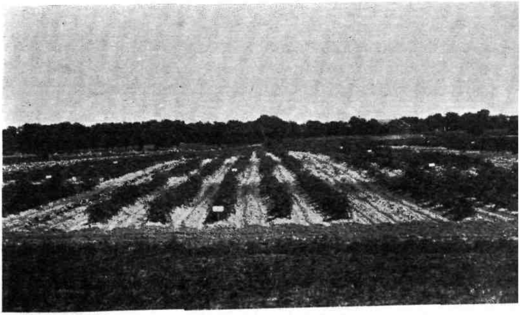


Fig. 2

General Views of Plots at Masonville, N. J. Fig. 1, Limed Plots. Fig
Unlimed Plots

REPORT OF WEATHER OBSERVATIONS

The weather observations were taken as usual by William Schieferstein.

The weather during the year was unusual in several respects. The total rainfall during the year was 53.79 inches, this being 5.03 inches above normal. The rainfall during June, 1920, was excessive, the total of 9.64 inches being 6.31 inches above normal. On June 29, 1920, a severe rain and hail-storm, accompanied by very high winds, caused considerable damage to fruit and other crops. Large trees were blown over and broken, while fruit was blown to the ground and badly cut by hail.

The snowfall also was above normal, the ground being covered with snow and ice during the greater part of the winter. The severe winter was followed by a late spring, with very unfavorable conditions for pollination during the season in which most fruit trees were in blossom. A severe sleet and snow-storm prevailed over a large portion of the state from February 4 to 7. The first week of July, 1919, was unusually hot, the temperature ranging from 90° to 98° F. for the first 6 days of the month.

The first killing frost occurred November 9, 1919, and the last killing frost was in April 11, 1920.

Table 1

Daily and Monthly Precipitation at the College Farm

DATE	July 1919	Aug. 1919	Sept. 1919	Oct. 1919	Nov. 1919	Dec. 1919	Jan. 1920	Feb. 1920	Mar. 1920	Apr. 1920	May 1920	June 1920
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1	....	....	.09	.42	.13	....	....	....	....	....	.36	....
2	....	....	....	.17	.87	....	....	....	....	.54	T	....
3	....	....	.11	.03	....	....	....	....	....	.04	....	....
4	....	....	T	T	....	....	....	.33	....	.12	.02	T
5	....	.09	....	....	.56	....	....	1.23	1.17	.34	....	1.69
6	1.11	.11	....	.07	....	T	....	.55	.71	T	....	.91
7	1.04	.19	....	....	....	.40	....	.19	....	T	....	....
8	....	....	....	....	....	.09	.13	....	....	....	.91	T
9	....	....	....	....	....	.43	.97	....	....	....	.04	....
10	.36	....	.03	.03	....	.71	....	.18	....	....	T	....
11	.06	....	.15	....	.12	....	T	....	....	....	....	.11
12	....	T*	.14	.94	.13	.29	....	....	.09	....	.21	....
13	.24	.04	....	....	.60	.09	T	.47	.98	.63	.28	.45
14	.02	2.14	....	.42	....	.22	....	....	.03	....	.46	....
15	....	.01	....	.17	....	....	....	.33	....	....	.09	1.76
16	1.07	.56	T	T	....	....	T	....	.07	.07	....	.77
17	.08	.05	....	.14	....	....	.11	....	.11	.45	....	T
18	.60	.98	....	....	....	....	....	....	....	.05	....	.78
19	.66	.45	....	....	....	.35	.17	.07	.12	....	....	.25
20	1.99	.04	T	....	....	....	T	....	.23	....	T	....
21	.44	....	....	....	....	....	.07	.09	....	.98	.72	.42
22	.64	....	T	.09	....	....	.02	.42	....	....	.27	T
23	.51	....	1.46	.07	....	....	.55	T	....	.38	T	....
24	.18	....	.13	.35	T	....	.47	.08	....	T	.03	....
25	....	.77	....	....	T	.05	.01	.01	....	....	.05	.27
26	....	....	....	.01	.56	....	....	....	....	....	.12	....
27	.23	.03	....	T	.08	....	.14	....	T	.08	....	....
28	....	....	....	.10	....	....	T	....	....	.60	....	....
29	....	....	....	....	.09	....	....	T	.05	T	....	1.50
30	....	.07	....	.07	.58	.04	....	....	....	T	....	.73
31	....	T	....	.05	....	....	....	....	....	....	....	....
Total	8.33	6.30	2.01	3.13	3.72	2.67	2.64	3.95	3.56	4.28	3.56	9.64
Normal	6.42	5.75	3.97	4.11	3.30	3.74	3.61	3.28	4.08	3.45	3.72	3.33

Total rainfall for year 53.79 inches.
Total snowfall for year 34.2 inches.
*T—Trace.

Table 2

Monthly Maximum and Minimum of Temperature From July 1, 1919, to June 30, 1920

	July 1919	Aug. 1919	Sept. 1919	Oct. 1919	Nov. 1919	Dec. 1919	Jan. 1920	Feb. 1920	Mar. 1920	Apr. 1920	May 1920	June 1920
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Maximum	82.71	79.4	76.96	72.3	52.83	37.0	31.13	36.1	51.51	52.55	69.45	78.26
Minimum	64.58	61.1	55.5	51.4	36.06	20.03	16.45	20.9	32.9	38.63	45.84	57.3

:PORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY

Department of Animal Husbandry

*FRANK G. HELYAR, B.SC., *Animal Husbandman.*

WILLIAM C. SKELLEY, B.SC., *Assistant Animal Husbandman.*

*Appointed October 1, 1919, to succeed J. Marshall Hunter, resigned July 31, 191

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Report of the Department of Animal Husbandry

FRANK G. HELYAR

The following changes in personnel of staff have taken place: J. M. Hunter, animal husbandman, resigned August 1, 1919, to take charge of Adolf Gobel's farm at Annandale. His resignation is a distinct loss to the institution and to the animal husbandry interests of the state. Mrs. Emily G. Mershon, stenographer, resigned September 1, 1919. Robert McIntyre, swineherd, died November 21, 1919. F. G. Helyar assumed charge of the department in October, 1919. John Thompson, of Highland Park, was appointed swineherd November 25, 1919. Wm. C. Skelley, instructor in animal husbandry, has acted as assistant animal husbandman since the beginning of the year.

The work of the department has been marking time. On account of the absence of Professor Hunter for military service in the fall of 1918, the herd of swine was cut down considerably and maintained practically as an instruction herd during the last season.

Only one experimental project was attempted in the summer of 1919, that of a comparison of fish meal with digester tankage as a source of protein supplementing the grain diet. Because of the illness of the herdsman and the assistant animal husbandman for several weeks, some mistakes occurred in the management of the experiment that make the results questionable. For this reason they will not be stated.

Two projects have been gotten nnder way during the spring of 1920; a study of the efficiency and economy of some of the buttermilk products advertised and sold quite extensively in New Jersey to swine growers; and a study of line-breeding as a method of establishing a strain or family of swine. Duroc-Jerseys will be used in this experiment which will cover a number of years' work, and the aim will be to improve the size, fecundity and vigor of the herd.

Hog Cholera

During the spring of 1919 all the pigs were given double treatment, serum and virus, when weighing 40 to 50 pounds. On July 23 a Berkshire pig was found dead in the pasture. Two days later another pig, a Duroc-Jersey, was found sick and soon died. A post-mortem examination failed to show positive symptoms of hog cholera, although it was strongly suspected from the symptoms presented. Meanwhile, other animals in the same lot as the Duroc-Jersey were taken sick, showing the same symptoms as the others. One recovered, four finally died, all giving positive evidence through characteristic lesions in the intestines and kidneys of hog cholera. The rest of the lot, 24 animals, which had been given double treatment, part of them on May 22 and the rest on June 9, were given the double treatment again on August 12. No further cases appeared.

No attempt is made to explain conclusively the cause for the outbreak. Several reasons might be given. First, the serum may not have been protective against the virus used. Second, the virus may not have been potent, and only a passive immunity gained from the serum. Third, competent research may develop that there are animals which do not have the power to acquire immunity as readily or as completely as others. The fact that only a small portion of the herd which was very carefully treated with the same serum and virus showed sickness makes it difficult to charge the technique or the serum and virus with the failure to secure immunity in the seven cases mentioned. As has just been stated, lack of correct laboratory information makes a more definite statement impossible.

Work With Sheep

During April Mr. Skelley assisted in the meetings held in Hunterdon, Warren, Sussex and Morris counties for the purpose of securing better marketing conditions for wool. At the same time arrangements were begun for the cooperative study of the cost of raising sheep in New Jersey. This work will be started in September, just before the breeding season.

Needs of the Department

While New Jersey will not be a beef or mutton-producing state to any considerable extent, yet the economic changes in the agriculture of the country indicate that a certain amount of these products will be raised under the intensive conditions of the East, particularly in special cases where by-products of some specialized branch of agriculture will provide cheap food. The Experiment Station should have information as to the economy of these practices and as to the best methods to

follow, so that it can serve those who desire to invest. The Experiment Station should have, in cooperation with the College, adequate barns for sheep and beef cattle and a flock and herd of these animals. It should also have adequate funds for the maintenance of cooperative work with farmers in the state in the raising of beef cattle and sheep.

There has been no extension specialist in animal husbandry. The department has answered such correspondence as has come to its attention, but has not spent research funds for other extension activity. At the same time there have been numerous calls for extension work which it has been impossible to attend to. The importance of the livestock interests of the state and the need there is for better methods of management necessitate an extension specialist, not merely to carry instruction to the livestock men, but also to acquaint the institution with the problems of these men.

7

REPORT OF THE DEPARTMENT OF POULTRY HUSBANDRY

Department of Poultry Husbandry

Harry R. Lewis, B.Sc., M.Agr., *Poultry Husbandman.*

Willard C. Thompson, B.Sc., *Assistant Poultry Husbandman.*

Ralston R. Hannas, B.Sc., *Assistant in Research.*

George H. Pound, B.Sc., *Assistant in Poultry Research.*

Elmer H. Wene, *Superintendent of Egg-Laying Contests.*

Morris Siegel, *Poultry Foreman.*

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Report of the Department of Poultry Husbandry

HARRY R. LEWIS

I. INTRODUCTION

During the last year the work of the poultry department has increased very materially. The after-war impetus which has been apparent in the poultry industry throughout the country has greatly stimulated interest in poultry keeping and the department has been burdened as never before with the requests for assistance, and very definite help and advice. To meet this demand, all of the staff have devoted considerable time to extension activities. The work has progressed in a very satisfactory manner. The research and experimental problems have been carried on as previously outlined and many short laboratory tests have been conducted. Two new developments have been accomplished which are of far-reaching significance. During the past winter the necessary legislation was passed enlarging the work at Vineland by the establishment of three egg-laying contests, i. e., two additional contests—one in North Jersey, and one in Central Jersey. These will be later discussed at considerable length.

A second new development was the granting of funds to the poultry department for the supervision and administration of poultry shows and the use of prize money for such shows, which service will contribute very definitely to the interests of the fancier and the poultry breeder. This legislation will be more fully discussed in the following portions of this report.

The poultry husbandman wishes to express at this time his appreciation to all members of the poultry staff for their assistance and cooperation in promoting the work during the past year. A number of changes have been made in the staff. The problem of keeping satisfactory helpers and assistants has been very acute, because of the attractive wages paid by manufacturing interests and the great demand for able men for other lines of production. Numerous changes have continually been made and it is a very serious problem to be able to keep a suitable staff to carry on research work.

Departmental staff meetings have been held at frequent intervals during the year with the result that the work is well organized, and greater cooperation and interest is secured on the part of the staff assistants.

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Future Plans

During the coming year it is anticipated that no great changes or new lines of work will be undertaken. It will require considerable time and effort to develop the contest idea and to administer the special legislation providing for prize money and the supervision of poultry shows. Next year will be a period of consolidation in which the entire work will be strengthened, more completely organized and everything done in order that the greatest benefit may be secured from the funds as spent. Continued efforts will be made to secure as much research data as possible from the contests, which, together with the research observations under progress at New Brunswick, should bring forth many interesting and practical results.

New Building Needed

The poultry department has an exceptionally fine field laboratory in the nature of a well-equipped poultry plant. It is, however, very seriously handicapped in laboratory facilities, class-rooms and offices and in office and laboratory equipment. The present poultry building is not even large enough satisfactorily to accommodate the research activities and the administrative force. No facilities are available whatsoever for educational purposes. Appreciating this need, the organized poultry interests of New Jersey have recently been in communication with the Board of Trustees and the Board of Managers of the State University with the idea of having them include in their budget this next year the request for a poultry husbandry building. The need is very apparent. It is hoped that $150,000 will be appropriated this coming winter for this purpose.

Financial Statement

As in past years the department is in large part maintained by the income from poultry and eggs sold at the state poultry farm. These eggs are sold to the wholesale trade and to members of the college and station staff. Every effort is made to run the research plant on a business basis, and care is taken that experimental results are not sacrificed for commercial gain, yet every effort is made to conserve and efficiently dispose of the products, so that the income of the department which is available for the maintenance of the department shall be as large as possible. The poultry farm itself is absolutely self-supporting, and in addition, helps to maintain the administrative offices.

Plan of Report

The detailed report of research activities of the poultry department

ribe

each research problem in great detail, but rather to give a report of progress where the work has shown sufficient results. The detailed results of these projects as they are completed have been and will be published in bulletin or circular form. The "Hints to Poultrymen," published by the poultry department, are also a valuable medium through which the results of these experiments are printed.

II. RESEARCH

In discussing the research activities of the department, it has appeared wise to group these projects according to the subject-matter involved, e. g., breeding problems, incubation problems, feeding problems, etc. Many of the problems studied and discussed in this report have been under study for a number of years, while others are of only recent origin. All of these projects are now active. In addition to the following the department is constantly carrying on many simple laboratory tests of short duration. In presenting the active research projects, it will be the procedure in this report to give the title of the project and the objects, following it with a brief discussion of the progress of the work.

The Amount, Distribution and Inheritance of Fecundity in the Domestic Fowl

Project A1-12

The objects of this project are:

A. To study the behavior of fowls with regard to the amount and distribution of egg production.
B. To study and determine the factors that influence the amount and distribution of egg production in domestic fowls.
C. To study the mode of inheritance of fecundity in domestic fowls and to make such matings as will test such mode of inheritance.
D. To develop families of fowls, carrying lines of high egg production, the progeny of such, in succeeding generations, to be distributed throughout the state at nominal cost, with the object of improving existing poultry stock.
E. To determine relations existing between the distribution of egg production and total yearly performance.

This egg-production project was started in the fall of 1912 and has been one of the most active projects of the department. The project has been carried on both at the State Poultry Farm, at New Brunswick, and at the Vineland International Egg-Laying and Breeding Contest at Vineland. Very detailed pedigree records have been kept for a number of years on from 2,000 to 3,000 birds each year. The measure of fecundity in this work has been the pullet production, or the number of eggs laid during the calendar year of 365 days, from

November 1 to October 31. In the development of this work at New Brunswick, Single-Comb White Leghorns and Barred Plymouth Rocks have been used. Both high and low-producing lines have been isolated and are being tested. The high lines especially have been increased in number during the past two years to such an extent that the department has been able to disseminate pedigree cockerels and hatching eggs in considerable number through the county agents to the poultry interests of New Jersey. During the past fall 250 pedigree cockerels were distributed at cost, and during the past spring 33,000 hatching eggs were distributed at a nominal price throughout the state in relatively small quantities to those who could use them to advantage.

In analyzing much of the data secured from this project with special reference to object E, the department is cooperating with the Station of Experimental Evolution, Cold Spring Harbor, L. I. Dr. Harris is analyzing the data through standardized, statistical methods and checking up the relation between distribution of egg production and total production. It is planned during the coming year to increase the work with Barred Plymouth Rocks under this project and develop larger numbers of high-producing lines which have already been isolated. During the present year the major portion of the time on this project has been spent on object B to get accurate and detailed data regarding the influence of the number of varying factors upon the amount and distribution of egg production, which results will shortly be published in bulletin form. During the coming year the activities under this project will be enlarged to include the work at the Bergen County Egg Laying and Breeding Contest.

Variation in and Inheritance of Egg-Shell Color

Project A2-15

The objects in this study are:

A. To determine the extent and nature of the variation in the shell color of eggs produced by certain standard breeds of poultry.
B. To determine and study the factors that influence egg-shell color.
C. To study the behavior of egg-shell color in inheritance.

Before the country became engaged as an ally in the World War a project was started in the department, to study the variation in egg-shell color in eggs produced by typical varieties of our commercial fowls, the factors affecting this variation, and the possible behavior in inheritance of this character. The problem is one of considerable scientific interest, for during many years in which our modern breeds of fowls have been in the formative period the wide variation in color of egg shells has been a puzzling problem. It is not only a matter of purely scientific interest, but also one of intense practical value, in that

the egg markets of our country today are demanding more and more that attention be paid to uniformity in color of eggs shipped, particularly on the first-class trade. Both these desires are in view; that is, to satisfy a demand to know why and how the egg-shell color varies, and to aid in determining some practical method of securing a greater uniformity of color in the eggs produced for market sale.

Since war conditions demanded that certain material changes be made in the direction of investigational work, this project was stopped for the period of the war. But since the return of the person in direct charge of the details of this project from army service, and the readjustment of the research program to a peace basis, it has been possible to resume this project.

A standard has been made containing 26 different shades of color, as found in the grading of several hundred eggs. It was found both most convenient and most accurate to make this standard by blowing the eggs and placing them in a cotton-padded, glass-covered box. This method has been serviceable and accurate.

Four pens of birds, each containing 16 carefully selected, typical females (pullets) of four well-known varieties, i. e., Barred Plymouth Rock, White Plymouth Rock, White Wyandotte and Rhode Island Red, were placed at the disposal of this project. These pullets were carefully trap-nested from their first egg, and each egg was marked with the hen number and date. Each egg has been carefully compared with the standard and charted down to the credit of the hen according to the color, each color in the standard having a number by which it is known.

The results of this work to date consist of the accumulation of a large amount of data with regard to the normal variation in shell color in these birds. No attempt will be made to assimilate these data or study its meaning until fall, or the expiration of the first year, after which time considerable elaboration of the project will be possible.

The Improvement of Poultry Through the Establishment of *Egg-Laying and Breed-Testing Stations*

Project A3-16

The objects of this project are as follows:

A. To establish in New Jersey three egg-laying and breed-testing stations, one to be located at Vineland in southern New Jersey, one in Bergen County in northern New Jersey, and one in the vicinity of Hightstown in Central New Jersey.

B. To develop these contests as egg-laying and breeding stations, each contest to continue for a period of 3 years, one contest to start each year.

C. To study the fowl's individual egg-producing ability and the factors influencing or affecting it.

D. To study the standard-bred quality of poultry, and to determine the best methods of improving it through breeding and selection.

E. To study through the breeding feature of these stations, the behavior of fecundity in inheritance.
F. To make possible the registration and advanced registration of poultry on a basis of standard-bred quality and productive ability.
G. To improve the poultry stock of New Jersey through the direct benefits of these stations to the contestants, by trap-nesting and pedigree-breeding of the original birds and the production of progeny from such birds, which are later returned to the owners for their own breeding purposes.

During the past 4 years the wonderful results which have been secured at the Vineland International Egg-Laying and Breeding Contest, and the growing demand for work in this line has made it necessary for the state of New Jersey to enlarge its activities in this respect with the result that during the past winter, legislation was enacted and appropriations granted to increase materially this work through the establishment of two additional egg-laying contest stations, one at Westwood, in Bergen County, which is to open November 1, 1921. The following is a copy of the act which was passed by the Legislature supplementing the old Vineland appropriation and under which the contests will now be operated:

CHAPTER 35.

AN ACT empowering the department of poultry husbandry at the State Agricultural Experiment Station to conduct three egg-laying and breed-testing stations, and providing for the locations thereof, and providing for an appropriation therefor.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

1. The State Agricultural Experiment Station is hereby authorized to conduct three egg-laying and breed-testing stations in New Jersey as a part of the regular research work of said Experiment Station and to employ such assistants as may be necessary to carry out the provisions of this act. Said egg-laying and breed-testing stations shall be located as follows: one in southern New Jersey in the vicinity of Vineland, Cumberland County, one in northern New Jersey in the vicinity of Westwood, Bergen County, and one in the central part of the State of New Jersey, the exact location to be designated by the said department of poultry husbandry of the State Agricultural Experiment Station.

2. The sum of $15,000, or $5,000 for each testing station under operation, is hereby appropriated annually to the State Agricultural Experiment Station for the maintenance and promotion of such breed-testing stations, providing that no part of the sums appropriated shall become available until the amount thereof has been included in either a supplemental or regular appropriation bill.

3. All acts and parts of acts inconsistent herewith be and the same are hereby repealed.

4. This act shall take effect immediately.

Approved March 22, 1920.

New Jersey's contests are unique, in that they are made possible through the highest type of cooperation. The following will give an idea of how they are supported:

1. Each contest plant is built with funds raised by private subscriptions from poultrymen, farmers and business men in the section of the state where it is located.

2. The State of New Jersey appropriates funds to enable the department of poultry husbandry of the Experiment Station to supervise the contest and to secure and analyze the great mass of valuable and original research factors which are made available by such a contest.

3. An entry fee of $50.00, covering a full 3-year period, is charged for each pen, which amount pays for prizes and publicity, and enables the contest to keep in close touch with the contestants.

4. The revenue from the sale of market eggs and stock sold to contestants during the yearling year goes toward the maintenance of the contest, paying for feed, labor and miscellaneous expenditures.

The experience for the past three years has shown us that this activity in New Jersey has done much to promote the general welfare of the poultry industry. The following are some of the very definite results of these contest activities:

1. The contests have brought before our state and nation the wonderful advantages which New Jersey possesses for poultry production. Already hundreds of newcomers are purchasing land and developing poultry farms in all sections of the state as a direct result of this national advertising. *Taxable wealth is being created.*

2. The contests have demonstrated the exceptional high quality of the poultry bred in New Jersey with the result that our poultrymen are receiving orders as never before for foundation stock, for eggs for hatching, and for baby chicks from all sections of this and foreign countries. *Foreign dollars are being brought into New Jersey.*

3. The contests are providing for the official testing and registration of poultry on a basis of their breeding and production, which opportunity has never before been available to poultrymen. *Poultrymen now have the same opportunity for breed improvement as do other livestock breeders.*

4. The contests, through the breeding feature and the exceptional production which has been secured, have demonstrated the results which can be secured through systematic breeding for egg production by small selected matings of high-producing hens. Already hundreds of farms are using registered birds from the contests to improve their egg production. *This means a greater money return to New Jersey poultry keepers.*

5. The contests have enabled the working out of more efficient rations and methods of feeding, resulting in a greater production at a reduced cost. *Conservation of food stuffs and cheaper poultry products are the result.*

6. The contests have made possible the working out of the relations which exist between the external characters of a fowl and her ability to lay eggs, with the result that poultrymen are now able to cull out inferior or boarder hens, maintaining the same egg production with fewer hens and at the same time they are able to select and breed the better hens. *This means greater efficiency in poultry and egg production.*

7. The contests have been and are demonstrating the advantages and superior qualities possessed by standard-bred poultry. *This means more and better poultry.*

8. *The exact money return to the state and people of New Jersey* is hard to determine. It has, however, been frequently and widely estimated by qualified persons from New Jersey to California that the first three years of the Vineland Contest alone has meant hundreds of thousands of dollars to the people of New Jersey in the way of increasing the taxable wealth of the state, through the increased efficiency in the poultry production and through increased business brought to poultry producers of the state.

New Jersey contests are known internationally for the excellence of their plan and organization and for the efficiency of their operation.

They are talked about and studied in every state in the union.

These contests are not only local in their benefits but are state-wide in their influence.

These *contests are open for the inspection* of visitors at all times.

Two phenomenal records have been made by the Vineland Contest during the past year. The third, or pullet year of the first Vineland Contest which closed October 31, 1919, was interesting in many ways. The first point of interest is the fact that these birds greatly exceeded the production of their mothers during their pullet year, averaging *178 eggs per bird, the entire contest, while the mothers of these birds,* two years previously, averaged 162 eggs. What was of greater significance is the fact that 540 Single-Comb White Leghorns, or all of this breed that were in the contest, averaged 192 eggs for the year, which, so far as the writer has been able to determine, is a world's record for breed production at any contest.

At this writing, the second contest which started November 1, 1919, is also making a high record, not alone in the total eggs laid, but in *the extremely high production which has been secured during the early* summer months. The birds at the contest this spring have exceeded the 70 per cent point in production for a number of weeks consecutively.

One of the most far-reaching branches of the egg-laying contests and their more recent development in New Jersey is the registration feature. These contests are providing to poultry keepers a basis whereby their birds may be registered as other livestock breeders have the privilege *of doing. The following is the basis on which birds will be registered:*

1. *Every bird entering the contest which is free from standard disqualifications*, and which scores at least 75, is eligible for, and will be issued a certificate of registration.

2. Birds will be entitled to advanced registration as follows:
   - a. All birds which, during their pullet production, lay 200 eggs or more, the pullet production being considered the eggs laid during the 12 months beginning November first of the calendar year in which they were hatched.
   - b. All yearlings will be admitted to the advanced registry which succeed in laying 180 eggs or more during their second laying year, which *shall begin November first of the year following that in which they* were hatched.

NOTE.—It is further understood that no birds shall qualify for advanced registration which do not come through the year in which the record was made, in a healthy, vigorous condition, with a body or live weight which shall be at least 80 per cent of the standard weight required for the particular breed or variety.

3. Advanced registry of male birds shall be based on the following qualifications:
   a. Any registered male that has at least 10 daughters that make records entitling them to advance registry shall qualify for advanced registry.
4. Records of merit for short-time tests will be awarded as follows:
   a. To all pullets producing 75 eggs or more from November 1 to February 28 (or 29 in leap years), inclusive.

The regular weekly and monthly publications to contestants and the particulars covering contest activities have been issued during the past year. The results of the first two years' work at the Vineland Contest have been published in a Bulletin 338 of the Experiment Station. The three years' work is about ready to go to press. Numerous "Hints to Poultrymen" have been issued during the year dealing with specific phases of the work. The contest plant, together with the birds and the contest staff, are used in the conduct of a number of other research projects which will be discussed in other places in this report.

The Improvement of Poultry Through the Organization, Aid and Superintending of Poultry Exhibitions, Including the Provision for Instruction in Poultry Raising and the Offering of Premiums.

Project A4-20

The following are the objects and purposes for which this project is conducted:

A. To encourage the greater production of standard-bred poultry in New Jersey through the holding of more and better poultry exhibitions.
B. To organize, aid and superintend such poultry exhibitions, in order to insure their efficient and sound conduct.
C. To conduct any educational meetings, and to stage educational exhibitions as a part of such exhibitions.
D. To offer premiums for excellence in quality of birds exhibited at such exhibitions.
E. To make a detailed study of exhibition quality, including methods of breeding and the preparation of birds for exhibition.
F. To maintain a classified list of winnings at the exhibitions of birds under this project.

Since this is a new project of the department, and since many local poultry associations are interested in its development, the following methods of procedure in the administration of this act is here given:

A. Eligibility.

1. Only local or state poultry associations which are actively and completely associated with the New Jersey State Poultry Association shall be eligible to receive the benefits of this project.
2. Only those associations which have for one year immediately previous, held a successful show, shall be eligible to receive the benefits of this project.
3. The benefits of this project shall not be available to more than one local poultry association in any single city or town.

B. Distribution of funds.

1. Of the total amount appropriated each year by the legislature pursuant to this project. 10 per cent shall be set aside for the overhead administration of said project, 15 per cent shall be set aside and used for the conduct of educational meetings and exhibitions, while the balance of 75 per cent shall be allotted to the various associations for use as premium money.
2. The allotment of said premium money shall be as follows for the current year 1920-21: Annual exhibition of the New Jersey State Poultry Association $750.00; annual fall poultry exhibition of the Trenton Inter-State Fair $450.00. For each of the six local poultry associations which held successful shows in 1919-20, $300.00, which shall be available as follows: Phillipsburg, Westwood, Vineland, Paterson, Gloucester, Hammonton.
3. The allotment of administrative and educational funds shall be in the same proportion as the distribution of premium money, designated in B 2.

C. Detailed procedure.

1. Application for benefits from this project shall be made in writing to the poultry husbandman of the Experiment Station on or before September 1 of each year.
2. Said administrative department shall determine the eligibility of said association and shall notify said association of the final decision, together with the distribution and allotment of funds to said association, provided this application is accepted.
3. Said administrative department shall submit suggestions relative to a uniform and sound method of allotting all premiums which shall be followed by each local association in making up these premium lists, it being understood, however, that the allotment of the premium money from this project shall be left entirely to the discretion of each local association.
4. The secretary of each local association receiving money from this project shall submit for approval to the poultry husbandman of the Experiment Station at least one month prior to the date of this exhibition, a complete premium list, together with detailed statements of how said prize money is to be awarded.
5. In awarding the state money derived from this project, the premium list shall contain the statement in offering said premiums that they are awarded by the State of New Jersey.
6. It shall be understood that all premium money paid from this project shall be paid irrespective of the size of class.
7. Said administrative department shall then arrange with the proper state authorities to have such amounts as may be decided upon set aside by requisition for such specific purposes.
8. At the close of the judging of all shows where this project applies, the secretary of the show shall file with the poultry husbandman of the Experiment Station an attested list of winnings in the classes where the money from this project was offered.
9. The poultry husbandman of the Experiment Station shall present said list to the proper official who shall mail individual checks to each winner.

Cooperating agencies and the part each is to carry.

In administering this project the Poultry Department has requested the cooperation of the Show Committee of the New Jersey State Poultry Association and of the New Jersey Association of the Poultry, Pigeon and Pet Stock Fanciers. For the year 1920-21 these advisory committees are made up as follows:

Fanciers	*State Show*
J. I. Lyle, Plainfield, Chairman	Harry C. English, Bound Brook, Chairman
W. F. Bast, Phillipsburg	Rufus Delafield, South Plainfield
Harvey E. Rogers, Trenton	F. M. Prescott, Riverdale
Newton Cosh, Vineland	Harvey C. Wood, Bound Brook
Louis G. Heller, Bridgeton	George W. Russell, Allentown
	C. D. Cleveland, Eatontown
	C. S. Greene, Lakewood
	Paul Springer, Bridgeton

Since there are many states interested in legislation favoring poultry shows and educational work with poultry husbandry the original act is given. There follows an exact copy of the legislative act through which this project was made available:

CHAPTER 201

AN ACT empowering the Department of Poultry Husbandry of the State Agricultural Experiment Station to arrange for and to superintend poultry exhibitions and to award premiums at said exhibitions.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

1. For the purpose of encouraging poultry raising in this State, the State Agricultural Experiment Station through the Department of Poultry Husbandry, shall arrange for meetings of persons engaged in the business of poultry raising. Such meetings may be held at the same time and place at which are held meetings of poultry associations of this State. At such meetings the said department shall provide for instructions in poultry raising and shall also arrange to organize, prepare and superintend exhibitions at which all recognized varieties of poultry shall be eligible to be shown. To promote the success of such exhibitions, it shall be lawful for said department, at any such meetings, at which no admission fee is charged, to award premiums to the exhibitors of poultry. The said department shall formulate all rules and regulations governing such exhibitions and the award of such premiums. The said department shall also arrange for the time and place of holding such exhibitions, but, if practicable, same shall be held in each of the counties of the State.

2. The sum of ten thousand dollars annually is hereby appropriated to the State Agricultural Experiment Station for the purpose of this act, *provided*, same shall not become available until and unless included in any annual appropriation bill.

3. This act shall take effect immediately.

Approved April 19, 1920.

This legislation and the appropriations which will be made available from time to time will be a powerful factor in enabling the poultry department to conduct interesting and valuable studies dealing with

the breeding and exhibition of poultry and through the educational features will enable the department to put the results of research work before poultry raisers of New Jersey in a very definite and far-reaching way.

The Amount and Causes of Embryo Mortality

Project B1-16

The following are the objects for which this project is conducted:

A. To determine the factors causing the mortality of chick embryos.
B. To determine the economic loss due to the prevalence of this mortality.
C. To evolve means of controlling and eliminating this condition.

During the past year work was continued along the lines of artificial incubation in a further endeavor to determine some of the causes of embryo mortality. An experiment was run on the number of times of turning eggs during artificial incubation.

The eggs used were produced during the same period by the same pens. They were held for two weeks previous to placing in the incubator. The incubator used was a Mammouth Blue Hen Incubator of 2,160-egg capacity. The machine has an automatic turning device. It is composed of trays of metal rollers resting on a grooved bar which runs the entire length of the machine. The bar is moved by means of a crank at one end of the machine, turning the rollers so that the eggs receive about a quarter-turn at each turning. There is a crank at one end of the machine so that all the eggs on one side can be turned at once. Each section of the machine contains one tray. One hundred and fifty eggs were placed on each tray at the beginning of the experiment. At the nineteenth day of incubation the eggs were changed from the roller trays to hatching trays which are similar to the trays in other machines where there are no turning devices. At this time, of course, all turning ceased.

There were six different methods of turning used. Two sections were selected in different parts of the machine so that a check could be had on the experiment. The eggs in two sections were turned twice a day; at 6:00 a. m. and 6:00 p. m., beginning with the first day and lasting until the nineteenth day. Two sections were turned five times daily, at 6:00 a. m., 11:00 a. m., 4:00 p. m., 9:00 p. m. and 1:00 a. m., beginning with the third day and lasting until the nineteenth day of incubation. Two sections were turned twice a day, at 6:00 a. m. and 6:00 p. m., beginning with the third and lasting until the nineteenth. Two sections were turned three times daily, at 6:00 a. m., 1:30 p. m. and 9:00 p. m., beginning with the third day and lasting until the nineteenth day of incubation. Two sections were turned twice a day, at 6:00 a. m. and 6:00 p. m., beginning with the third day. Turning

In all

ıese different methods of turning, an endeavor was made to divide ıe 24 hours in each day equally.

All sections were turned exactly alike during the incubation period. ioisture trays were kept in each section from the start to the finish, ıd the temperature was held constantly at 103 degrees.

The percentage of hatch of fertile eggs were as follows:

73.1 for the sections in which the eggs were turned twice daily from the 1st to the 19th.
62.1 for the sections in which the eggs were turned five times daily from the 3rd to the 19th.
61.6 for the sections in which the eggs were turned twice daily from the 3rd to the 19th.
62.0 for the sections in which the eggs were turned three times daily from the 3rd to the 19th.
53.3 for the sections in which the eggs were turned twice from the 3rd to the 12th.
32.5 for the sections in which the eggs were turned twice daily from the 3rd to the 6th.

These figures, in each case, are an average of the hatches in each ction in which the eggs were turned alike, for example: 73.1 per cent ıtched is an average of the two sections first listed. These figures may seen more clearly in table 1 where the number of infertile eggs and ad eggs removed at the candling periods also are given.

The figures obtained would seem to show that the number of times day the eggs are turned is not of such importance as the period ıring the hatch at which they are turned. It has always been conlered that the first week is a vital period of the hatch, especially ıere the turning is concerned, because at this time the germ is most cely to stick to the shell unless the eggs are turned. This is quite ue, but at the same time it would appear that turning during the tire period of incubation is necessary, i. e., until the nineteenth day. ıis conclusion would seem natural from the figures given in the table; r example, all eight sections in which the eggs were turned either om the first or third days of incubation until the nineteenth, avaged over 60 per cent hatch, while the four sections where the turng was begun at the third day and continued until either the sixth twelfth day, averaged less than 60 per cent. Those that were turned ly until the twelfth day averaged 53.3 per cent, and those that were rned only until the sixth day averaged but 32.5 per cent. It would ɜm, then, that turning should be practiced until the nineteenth day, e number of times a day which they are turned being purely arbiıry. The possibility is, however, that better results would be obned by turning from the first day on, as is shown by the first two tions listed which averaged 11 per cent better hatch than the best o sections which were turned from the third day on. This may be en in another way also, when we consider the number of eggs reoved at the candling periods. There were 33 eggs removed from the o sections which were turned from the first to the nineteenth, inclue. This was the smallest number of eggs removed from any two

ions. The other sections, running by twos: 52, 57, 44, 44, 55. ere were also less chicks dead in the shell at hatching time in these sections than in others. The conclusion from this experiment uld seem to be that eggs should be turned at least twice a day, from *third day at the latest until the nineteenth day at the earliest,* with sibly better results when eggs are first turned at the first day of in- ation.

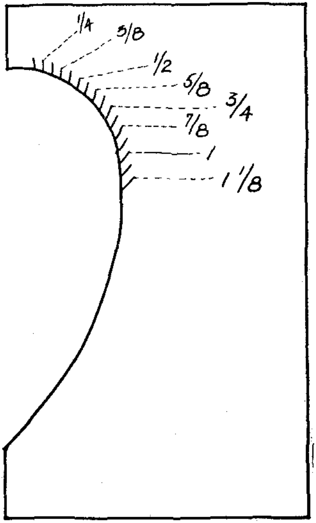

FIG. 1.

DIAGRAM OF CARD USED IN MEASURING SIZE OF AIR CELL IN EGGS.

)uring the past two years work has been done in measuring the of air cells at different periods of the hatch. Since the amount of sture which is used during incubation determines to a very large ent the size of the air cell, the size of the air cell, therefore, is an ication of when to supply moisture to the eggs.. Several thousand s have been measured in the past two years in an effort to determine it should be the proper size of an air cell at various periods of a ch.

The method used was as follows: One side of a cardboard was cut out about the shape of an egg. From the point which marked the top of the egg, measurements were made every sixteenth of an inch down. These points were drawn by means of a compass across to the side of the cardboard where marks were made to indicate the measurement. A copy of the card is shown herewith. The only practical means of measuring the air cell seems to be measuring the depth; that is, the depth at the middle of the air cell. This card at candling time was held to the egg and the point on the card from which measurements were taken was at the top part of the middle of the air cell. It was found necessary to do this because the air cell has a tendency to develop at an angle rather than horizontally. It was desired to get some method which would be easy for poultrymen and general farmers to use without a great deal of intricate technique. This seemed to be the simplest method available.

After making a large number of measurements it was found that at the eighth day of incubation the depth of the air cell was 23/32 of an inch, at the fourteenth day it varied between 25/32 and 13/16 of an inch, and at the nineteenth it varied between 15/16 and 31/32 of an inch. These measurements were taken from the best hatches here at the Experiment Station for the past two years. If the air cells are larger than the measurements given at the periods mentioned, more moisture is recommended to be used in the incubator. If the air cells are smaller the poultryman is advised to keep moisture away from them. Since the moisture is one of the great problems of artificial incubation, there must be some definite means of telling when it should be supplied, and this seemed the only method available. Expressed in terms of the relative size of the eggs, they are: A little less than one-third the size of the eggs at the eighth day, one-third the size of the eggs at the fourteenth day, and a little less than one-half, approximately two-fifths, on the nineteenth day. This phase of the work will be continued from year to year in an effort to find an absolute means of controlling the moisture problem, thereby eliminating, as far as possible, the element of chance in artificial incubation.

The Influence of Quality and Quantity of Rations Upon Egg Production

Project C1-15

The following are the objects for which this project is being conducted:

A. To determine the proper amounts and the most efficient sources of protein in the ration for laying hens.

B. To determine the relative efficiency of rations carrying varying amounts of meat scrap as a source of animal protein.

C. To study the effect of feeding varying proportions of mash and grain to

Table I

Effect of Different Methods of Turning Eggs on Percentage of Hatch in Artificial Incubation

Section	Turned	Number Set	Number Infertile	Dead at Seventh Day	Dead at Fourteenth Day	Dead at Eighteenth Day	Dead in Shell	Number Hatched	Number of Cripples	Total Hatch	Per cent Hatch of Fertile Eggs	Average per cent
2	1-19 days twice	150	4	1	3	5	26	102	7	109	74.6	73.1
8	1-19 days twice	150	5	4	5	6	26	100	4	104	71.7	
4	3-19 days 5 times	150	9	5	8	4	18	101	1	102	72.3	62.1
12	3-19 days 5 times	150	6	4	10	6	48	66	7	73	52.0	
1	3-19 days twice	150	8	8	6	5	21	95	5	100	70.4	61.6
9	3-19 days twice	150	6	12	9	3	44	69	7	76	52.8	
3	3-19 days 3 times	150	8	5	6	6	26	93	6	99	69.7	62.0
7	3-19 days 3 times	150	5	4	8	2	52	72	7	79	54.3	
6	3-12 days twice	150	5	5	12	8	45	70	5	75	51.7	53.3
10	3-12 days twice	150	3	3	5	3	50	75	6	81	55.0	
5	3-6 days twice	150	4	4	8	6	70	52	6	58	39.0	32.5
11	3-6 days twice	150	4	4	7	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

D. To determine the factors influencing the amount of food consumed by laying hens.
E. To study from year to year miscellaneous nutrition problems which may appear as a result of the completion of certain phases of this project.
F. To evolve and recommend to the poultry fraternity of New Jersey improved and efficient rations for egg production.

This project was started in 1915 and has been one of the major projects of the department from that time. Numerous results of this work have been published in annual reports, "Hints to Poultrymen" and bulletins. The present project which is being carried on this year includes a study of the influence of the proportion of mash and grain fed to laying hens upon egg production, together with the influence of varying amounts of meat scrap in the laying mash. The study this year is being conducted with 900 birds, divided into 18 flocks of 50 birds each. Some very distinct and definite results are being observed. Since this project does not close until November 1, 1920, it is impossible to report definitely upon it at this time, but it is expected with the conclusion of the year's work, a sufficient amount of valuable material will be available to warrant the publication of the results for the past few years in bulletin form.

The Influence of Artificial Illumination Upon Egg Production

Project D1-19

The following are the objects of this project:

A. To determine the influence of artificial illumination upon egg production when applied to
   1. February-hatched pullets.
   2. April-hatched pullets.
   3. Yearling hens.
B. To determine the material, labor and operating cost of providing artificial illumination when various methods of lighting are used.
C. To determine ways and means of solving the additional labor problems involved in running artificial illumination on layers.
D. To determine the general efficiency and practicability of the entire lighting question.

Started during the fall of 1919, this project has not yet attained sufficient completeness to warrant the publication of results at this time. During the past year a Western-Electric Lighting Unit was installed on the State Poultry Farm, and 1,100 Single-Comb White Leghorns, including yearling hens and February and April-hatched pullets, were put under lights in an effort to study the influence of illumination upon various ages of birds, and further to study the influence of different methods and time of operating the lights. Barn lanterns and gasoline lanterns also were tested during the past winter. Only flock records were kept in the development of this project. In

general, it may be said that artificial illumination, if properly planned and carried on, is a powerful factor for increasing production and profit with poultry. It must be remembered, however, that when birds are put under lights they are kept under more or less artificial, unnatural and unseasonable conditions, hence any faulty methods of management or any mistake in their care will react disastrously to the health and production of the flock. While the year's records under this project are not yet completed, and it is impossible to show final figures, yet the results were so conclusive during the past winter that the following suggestions may be made at this time:

A. All birds kept under lights should be graded as to laying quality and condition. Pullets of different ages and hens should be kept in distinct flocks since they must each be handled in a very definite way according to their condition.

B. When operating lights on pullets they should be started November 1 and run until April 1. When running lights on hens, they should not be started until January 1 and run until April 1. When lights are turned off in the spring it must be done gradually, about 10 minutes' change in a single day is all that it is safe to make.

C. Morning lights are superior to evening lights or to a combination of morning and evening lights. The best time is to start the lights in the morning about 4:00 a. m., or at such a time that 14 hours of light and 10 hours of darkness may be given the birds. Experiments are under way to test out an evening feeding from 8:00 to 9:00 o'clock with no other artificial illumination. So far the results seem very gratifying.

D. The birds under lights should be fed grain at least four times a day to keep them active and exercising, the times depending upon when the lights are used.

E. Birds under lights should be fed more heavily on grain than birds not under lights, otherwise a reduction in body weight will follow and the birds will become run-down in the spring. During the winter months 14 pounds of grain per day to each 100 hens under lights is the correct amount.

F. Electric lights are far superior in efficiency, labor and cost to any other type. Two 25-watt lights to a Standard Multiple Unit 20 by 20-foot house is the best distribution of illumination. They need not be on suspended cords but can be attached to the purline, each light being provided with a wide-angled reflector. Barn lanterns do not give sufficient light to accomplish the greatest benefit, and there is the additional labor of operating them. Gasoline lanterns, while tried out extensively, do not prove efficient, due to the great amount of labor and the fact that the dust which continually rises from the birds scratching in the pen clogs up the air intake of the lantern, in spite of frequent cleaning.

G. Simple time-switches may be made by using alarm clocks and lever switches which are much less costly and far more efficient than expensive time-clocks and time-switches.

H. It seems that birds will react in from 7 to 10 days immediately following the application of artificial illumination and that during the winter months birds under lights, if properly handled, may be expected to increase their production approximately 100 per cent over unlighted flocks.

I. If birds are handled properly under lights, there should be no expectation of moult or check in production when the lights are finally turned off, about April 1. At that time the natural daylight will have caught up with the artificial light and the birds will not know of the change.

Birds under lights are no more subject to colds or canker or to other diseases than are unlighted birds. As a matter of fact, the general results seem to point to the fact that they are more resistant to these infections. Definite figures covering the results of this project will soon be published in bulletin form.

Poultry Flock and Farm Management Studies

Project D2-17

The following are the objects of this project:

A. To determine the efficiency of modern poultry practices as measured by labor income, including:
   1. Farm poultry management.
   2. Commercial poultry management.

B. To determine itemized inventories and values needed to organize and equip a suitable plant for poultry and egg production.

C. To determine the size and organization of flocks best suited to poultry and egg production.

D. To determine the items and amounts entering into the expenses of operating a poultry plant.

E. To determine the items and values which go to make up the sources of revenue in operating a poultry plant.

F. To determine the financial possibilities and profit resulting from poultry raising both as a farm and as a commercial enterprise.

G. To determine the factors which influence profits and the relative importance of such factors.

H. From the data available from such studies, it will be the purpose to show the changes which are taking place in the business side of poultry keeping year after year, and with the information at hand, it will be the purpose to predict conditions which may be expected in the future.

Started in 1917 this project has been continued and developed in succeeding years, the results over succeeding years being compiled with the purpose of publishing them in bulletin form. Figures from this project have been used as a basis of a number of "Hints to Poultrymen," which have been published during the past year or two. Three-year records have now been secured on the commercial poultry unit of 1,100 birds on the State Poultry Farm, and also on the typical farm flock maintained on the farm. This is distinctly a standardization project which is aimed at securing accurate figures regarding details of commercial and farm flock management. Many of the recommendations which this department is in a position to make continually to poultry keepers are based upon the findings secured from this survey.

A Complete Study of Contagious Epitheliosis

Project X1-19

The following are the objects of this project:

A. To ascertain the true nature of the outbreaks in New Jersey.
B. To determine the cause of the disease in its various forms.
C. To discover the most satitsfactory methods of control.
D. To study the most successful methods of treatment.
E. To apply all information gaiued through a study of this project in practical control of outbreaks in New Jersey.

During the past year an organized attempt has been made by th department to aid the poultrymen of the state in controlling the rouj chicken-pox and canker group of diseases. The large toll that thes diseases have taken from New Jersey poultry flocks, big and smal commercial and back-yard, no doubt reaches hundreds of thousands o dollars. This immense loss to the industry is due to the followin factors, it would appear, from a study of the general infection through out the state:

A. Mortality caused by a virulent infection with the organisms that caus these diseases, whatever it may be. The contagious eye roup forn has caused the highest mortality and greatest losses. The canker form penetrating the trachea, lungs and air passages, also has killed man birds.
B. Egg production is stopped immediately after these diseases get a foothold in the flock, and this, of course, causes immediate loss of salable product from the flock. This fact would seem to indicate that the infectio might be in the blood stream.
C. Every form of the disease, if it does not prove fatal, lowers the natura strength, vigor and vitality of the fowls affected to such a degree tha they not only do not come back into productive condition again, at least for a long time, but are incapable of resisting the causative agencies of disease which may later surround them.

The treatment of these various forms of disease has been discussed in "Hints to Poultrymen," for August, 1919.

It was the hope of the department that the treatment and prevention of these diseases might be effected by the preparation of a vaccine from actual cases, and it was with this problem that the laboratory staff of the department began a series of experiments in the fall of 1919. At the outset, it should be realized that such an undertaking must meet with many difficulties of a serious nature. In the first place, the organism or group of organisms that are responsible for this disease has never yet been isolated, described or characterized. This has meant that the preparation of a vaccine, for either therapeutic or prophylactic purposes, must be built on a rather uncertain basis. The published work of investigators in other states, as Beach of California, Brumley and Snooks, of Ohio, and Mack and Records of Nevada, as well as others, was carefully studied. That so many well-trained scientists had found great difficulty in the problem accented the fact that the solution might be a long way off. At the present time there are several trained scientists in various parts of the country working along similar lines, trying to determine some method of practically helping the poultry raisers to meet this loss-producing element.

Several typical cases from different sections of New Jersey were procured from cooperating farmers, careful diagnoses made, and material from the sores used in the preparation of the vaccine. The experience of the year has suggested many necessary changes in methods and technic.

The vaccine was prepared in the laboratory under difficulty, due to a shortage of equipment and labor, and the necessarily short time in which the work had to be accomplished. Some thirty different poultry farms in the various counties of the state offered to cooperate in this work by allowing the representative of the department to make the necessary inoculations and vaccinations on birds in their flocks. On the average 200 birds were set aside on each farm, 100 to be vaccinated and 100 to be kept as a check. One cubic centimeter of vaccine was used in each case, the inoculation being made under the skin on the breast. In some cases opportunity was afforded to try the vaccine as a treatment in cases of sick birds, and in such cases a double dose was administered. This work was done during September and early October.

The following points would seem to summarize the results of this rather extensive experimental project, and it should be distinctly borne in mind that it was entirely a research project from start to finish.

1. Where the vaccine was prepared from actual cases from a given flock, and the vaccine used on the actual cases on that farm, the results indicated a fair degree of help rendered. Especially was this true when a double dose was administered and again repeated after six days.
2. The value of the vaccine when applied to pullets some time previous to the appearance of the diseases was of questionable worth. This may have been due to:
   a. The worthlessness of the vaccine.
   b. The short time in which it may have a protective value.
   c. Insufficient dosage.
   d. Insufficient strength of vaccine.
   e. Other factors not understood, possibly due to the fact that the vaccine was prepared in ignorance of the real character of the organism.
3. There was sufficient indication of protective value in the vaccine to warrant extending the plans and preparations for an even greater experiment during the fall of 1920. By no means did the negative results secured in some of the flocks inoculated prove the impossibility of the use of some such system as this vaccine in the control and treatment of the diseases. Rather were they encouraging, because in the experience many new and valuable points were learned.
4. The disease group here referred to has many more complications than a casual or superficial observation would reveal. Considerably more time and effort must be spent in ferreting out the exact nature of the diseases, their pathological phases in particular.

There is no more important branch of work to be undertaken, but it must have much time, labor and effort spent upon its study before so gigantic a problem can be effectually solved.

Observations Concerning the Distribution and Prevalence of Poultry Diseases in New Jersey

Project X2-14

The following are the objects of this project:

A. To study the poultry disease cases which occur, and are brought to the attention of the department of poultry husbandry through the following sources:
   1. Fowls dying on the State Poultry Farm at New Brunswick.
   2. Fowls dying at the Vineland International Egg-Laying and Breeding Contest.
   3. Fowls brought to the poultry department by representative poultrymen of the state for post-mortem examination.

B. To study all diseased birds with reference to the location of the disease, types of disease, prevalence in districts and seasons, together with ante- and post-mortem conditions.

C. To study and make a classified tabulation of all diseases found.

In every productive agricultural industry there are certain factors that arise to hinder the development of that production in greatest possible quantity. In poultry production among the factors that lessen profits and make efficient production more difficult is that of disease. Many poultrymen have said during the past year that if the problem of disease prevention could be completely solved the poultry industry of the state would go forward by leaps and bounds, as that factor was the greatest enemy of success in this field of agricultural endeavor. Several trips into various parts of New Jersey fully convince one of the absolute truth of these assertions, and further, that the disease problem is a much more complicated one than it appears to be on first consideration. It is considered so important a part of the poultryman's program to fight disease and to develop and maintain the health of his birds that considerable time and effort has been spent during the past year in studying the problem. The logical starting point to an investigation of this kind is to ascertain just what the field is and just what it contains. With the idea in nind of broadening our knowledge along these lines, preparations vere made to make a close and detailed study of as many cases of oultry diseases as might be possible. Neither time nor labor pernitted beginning this observation in any definite and organized way intil March 1, 1920. Therefore, this report will discuss the results f disease investigations between that date and June 1, the date of he preparation of this part of the annual report. It is, therefore, irgely a resume of the conditions during the spring season.

It was desired to have as many cases of diseased birds as possible n which to make the required studies and examinations, because in is way alone could sufficient evidence be gathered to allow the rawing of conclusions and estimation of percentages.

The general plan of this project has been to gather the following data:

A. The section of the state from which the specimen came, for, in so far as possible, it was desired to group the diseases found in the several sections together to determine whether or not there were regional types of diseases, epidemics, or troubles that seemed to be linked up more or less definitely with climatic or regional conditions that prevailed in the various parts of the state.

B. The number of cases in the flock from which the specimen sent in for examination came, because in many instances the cases actually examined represented epidemics where several similar cases had been found, and therefore an important fact would be registered.

C. The fullest description possible of the actions and appearance of the birds before death, as this information is so often essential to the making of a differential diagnosis. It is this point upon which it is hardest to secure full information, and it is urged that anyone requesting the aid of the department in cases of poultry disease bear in mind the importance of furnishing this information.

D. The external symptoms, or body conditions, exhibited by the cases just prior to opening for post-mortem. It has been found that certain observations taken at this point were of great value in making the final diagnosis of the trouble. Because of the importance of this point an outline is here given of data that should be taken. Every poultryman can well get into the habit of noticing these things about the birds that die from his flocks, for their consideration will often lead to a more or less sure identification of trouble and its causes. It is ever true that the poultryman should learn some lesson from every case of death in his flocks. Of course, it is necessary to gather this data as soon as possible after death, because, especially in hot weather, changes take place so rapidly that decay may overshadow the real conditions due to the ravages of the disease:

1. Examine head parts:
   a. Color, size, development and texture of comb.
   b. Eye, as to prominence, brightness, size, infection.
   c. Wattles, ear-lobes, and face for pot-marks, favus, etc.
   d. Mouth and throat, for canker, diphtheria symptoms, etc.
   e. Proportions of head, as long and narrow, or "crow-beaked."
2. Crop condition, whether empty or full, as the indicator of appetite.
3. Flesh condition, particularly on breast, thigh-bones, and neck.
4. Condition about vent, such as diarrhea, sores, etc.
5. Condition of plumage, particularly feathers on head and neck.
6. Presence or absence of lice of various types.

E. The examination of the internal organs and parts, known as a post-mortem, in which examination most careful inspection of the various systems of the birds' bodies should be made, because it is in this part of the examination *that the great bulk of the specific symptoms are developed and* shown.

With these data at hand and arranged in a tabulated form so as to do away with cumbersome and awkward mass of statistics, the study of the occurrences of the various types of poultry diseases and poultry troubles was made relatively simple and easy. The major reason for keeping this information during this past spring has been to analyze the mortality annually suffered during that season on poultry farms. It is a recognized fact that there will be a certain percentage of loss

among adult fowls during the year, and that the heaviest toll will be taken usually during the months of March, April and May. It was thought that, as it was possible to start this observation and examination work at that time, the results would give us a clearer understanding of the causes of the "normal mortality," if such a term may be

Table 2

List of Poultry Diseases Diagnosed

NAME OF THE TROUBLE	Number of cases found during			
	March	April	May	Total
Abdominal dropsy	2	1	1	4
Acute indigestion	1	0	0	1
Anaemia	4	5	5	14
Bacillary white diarrhea	9	0	0	9
Bronchitis	1	0	0	1
Canker	3	8	9	20
Congestion of brain	4	2	3	9
Congestion of lungs	0	2	0	2
Crippled, injured, killed	1	1	2	4
Diphtheretic roup	1	0	0	1
Egg bound	0	0	1	1
Eye roup	15	36	28	79
Flesh tumor	0	0	1	1
Gangrene of ovary	0	0	1	1
Gout	0	1	2	3
Hemorrhage, or bled to death	8	5	6	19
Intestinal disorder	0	0	1	1
Liver troubles, other than tuberculosis	5	4	10	19
Natural breakdown, low vitality	4	3	5	12
Ovarian tumors and complications	8	18	5	31
Paralegia	1	1	0	2
Peritonitis	12	11	8	31
Pericarditis	0	1	2	3
Pneumonia	0	0	2	2
Poisons (inorganic)	0	0	1	1
Prolapsis of oviduct	9	13	17	39
Rheumatism	3	0	0	3
Tuberculosis	4	6	1	11
Worms (intestinal)	1	0	6	7
Undiagnosed	2	6	4	12
Total of 29 different disease groups	98	124	121	343

ised. Of course, during the accumulation of these data, certain dis-ases appeared with sufficient regularity and in great enough numbers o warrant considering them as epidemic in nature, but the great ma-ority of cases diagnosed were isolated and unrelated cases, good xamples of the "normal mortality." It is considered an important

thing for every poultry raiser to know what agencies he may expect to enter his flock to take out members of it from time to time as the year advances. For this reason these facts are written into the annual report of the department in some detail.

The examination of all the cases of sick and dead birds enumerated below was performed according to the outlined steps mentioned above in so far as was possible, and after each examination was completed the diagnosis, or explanation of the cause, was made with as great accuracy as possible. A separate report was made on each case.

The list of poultry diseases and troubles diagnosed in the course of the three months is given in table 2.

This table contains several things that are of interest which may be of considerable importance in helping poultrymen generally to understand what the forces are that cause a certain death rate during the spring season in their laying and breeding flocks. The following statements are offered as a summary of the situation as found during the spring of 1920. It should be remembered that these cases came from all parts of New Jersey.

A. The scourge of poultrydom in New Jersey—the group of contagious diseases commonly referred to as roup, chicken-pox and canker and often named contagious epitheliosis, appeared in quite large percentage. The actual number of cases enumerated above simply indicate the cases actually handled, but they represent fully ten or fifteen times that number of cases in the flocks from which they came. It is interesting to note that the bulk of these cases were primarily eye roup cases, with some canker cases, most of which were lung and wind-pipe (trachea) infection. Little of the dry chicken-pox was seen. The writer has heen in touch with leading poultrymen in other sections of the country, and it seems that in the bulk of these other sections this dry chicken-pox form is found in greater frequency than in New Jersey, but undoubtedly it is present in many of the infected flocks reported above, where the eye roup has developed to such an extent as to hide the symptoms of the other from the casual observer. These diseases come in epidemic form to certain sections; that is, when they do appear the outbreak is not limited to scattering cases, but it is general in its infection of the flocks entered. Letters received during the year, as well as these cases, indicate that from the early part of the fall of 1919 there were more or less severe epidemics of roup, chicken-pox and canker. In another part of this report the case of the state against contagious epitheliosis is discussed in some detail.

B. One of the most important items brought out by this table is the large number of cases of ovarian trouble and peritonitis (which in the large percentage of cases examined originally started from ovarian trouble). This situation is serious and deserves consideration.

1. The ovarian trouble referred to consists of the miscarriage of ova (yolks) from their normal route from the ovary to the funnel of the oviduct, the accumulation of such misplaced material in flase sacs as hard, yellow, decayed or putrified matter, or the breaking of the yolk sacs and the emptying of the food material into the abdominal cavity (this finally decays and causes inflammation of the peritoneum, peritonitis).
2. When the material which has not followed in the normal path of development does accumulate in mass it is called ovarian tumor. When it reaches a certain size it evidently causes serious pressure on the vital organs. which eventually causes death. This is

one of the explanations of sudden deaths among birds that were apparently good layers. In some cases a contributing cause of mortality may be the absorption of poisonous by-products from these decayed masses into the body.

3. The cause of the miscarriage of the ova is not well understood, but the evidence seems to indicate that:
   Some individual birds cannot stand up under forcing for egg production.
   There may be tendency among present-day poultry keepers to increase the average number of eggs produced per bird per year by feeding and management factors rather than by building up such productive capacity first through breeding in this direction. It is well that we know how to get a large number of eggs out of our layers, but is it not possible that we may be trying to accomplish this too rapidly for the physical strength of our birds? These ovarian troubles are primarily diseases of our good birds, rather than of our poor layers or producers.
   Particularly in the spring and especially before the hens are turned out on green yards, there is a tendency for constipation to develop in the flock, and this seems to cause inflammation of the egg-producing organs.
   There may be some inherited weakness in certain individuals of the organs that have to do with egg production.
4. There is no known method of treating birds afflicted with any form of these ovarian troubles since
   They are usually not diagnosed or recognized until a post-mortem examination has been made.
   They often do not show any external symptoms prior to death.
   The very nature of the symptoms that develop in these cases would indicate an impossibility of treatment.
5. The prevention of further trouble, after characteristic cases have been cited in a flock, is a matter of importance, but unfortunately one of difficulty. Probably if the number of cases becomes alarmingly large something must be done in the matter of reducing forcing rations, or in furnishing succulence in the ration.
6. A poultryman may normally expect a considerable number of cases of ovarian disorder during the spring, and can chart these up to the normal losses to be expected. It is only in unusual cases that an excessive number of cases will occur in any one flock.
7. An abnormally large number of cases of this kind in any one flock probably means that sufficient attention has not been given to breeding for increased egg-producing capacity to keep pace with advancement in the knowledge and practice of feeding and managing for egg production.

C. During the spring there always occur several cases of prolapsis of the oviduct. This disease means a more or less complete eversion of the lower end of the oviduct through the vent. Constipation is probably the main cause.

D. Probably the other item of real economic importance that this table brings out is the increasing danger due to the infestation of round white worms that is appearing in various parts of the state. In most of the cases examined, which, by the way, again represented serious infestations of considerable size, the infesting worm was ***Heterakis perspicillum***, a round white worm averaging about 2 to 3 inches in length. Usually these worms were found in large numbers in the entire length of the intestinal tract.

1. The external symptoms shown by worm-infested birds varied very widely, but in the majority of cases the birds gradually became thin in flesh, weak, more or less anaemic, sometimes apparently

paralyzed, witb possibly some diarrhea of a dry, whitish type, and lost egg production.

2. The infestation is apparently rather slow in getting to a serious point; in other words, the infestation does not show any effects for some time after it has taken place.
3. The worms are given off through the droppings and are spread through the consequent infection of food and litter. An infestation will be recognized by finding the worms in post-mortems and on the dropping boards.
4. The best treatment known at present is one that has been tried for several years for various worm infestations, namely, the tobacco treatment. Steep 1 pound of tobacco stems in enough water to mix up a wet mash for 100 birds, for 1 hour, then mix the mash, feeding it sparingly to birds in the afternoon about 3 o'clock. It is preferable to have the birds hungry by withholding the morning feeding. After 1 hour give another wet mash in which has been placed 1 pound of epsom salts per 100 birds. The tobacco mash will kill the worms and the salts mash drive them out of the system. Get up early the next morning and clean the dropping boards thoroughly, as the droppings will be full of the worms, many of which may not be dead, or the eggs within them may not be dead.

E. There is some evidence that ovian tuberculosis is more generally distributed throughout the state than some have supposed, but the occurrence of cases has been scattered and not intense in any one area. It is well to take a note of warning in this regard, however. Tuberculosis is characterized by emaciation, bright eye, the liver spotted with raised yellow, hard, deep lesions, also a greatly enlarged liver and spleen. Use care in buying new stock to avoid introducing infected stock. Remove all birds going light in weight and flesh as soon as noted. Practice rigid sanitation at all times.

In addition to the above cases there have been the usual cases of baby-chick troubles, including diarrhea, leg weakness, crowding and toe-picking. The great bulk of these troubles arise from a lack of proper care of the chicks during their first two weeks. To counteract this it is suggested poultrymen having baby-chick troubles give more study to literature available on the subject.

The post-mortem and disease diagnosis work will be continued through 1920.

Control of Bacillary White Diarrhea

In certain sections of this eastern part of the country there have been very considerable losses each year in baby-chick flocks due apparently to the ravages of a contagious disease which has had as the most prominent symptom a severe and acute diarrhea. In 1899 Dr. Leo F. Rettger, bacteriologist at Sheffield Scientific School, Yale University, and the Connecticut Agricultural Experiment Station at Storrs, isolated the specific organism which was found to cause this trouble. This organism, *bacterium pullorum*, has been described fully in certain bulletins issued by the Storrs station. Quoting briefly from these publications, we find that this bacterium is "a long, slender bacillus, with slightly rounded ends, non-motile, non-liquefying, non-chromogenic,

facultatively anærobic, gram negative, non-spore-producing (at least not observed)." The infection of *bacterium pullorum* has spread rather rapidly through the poultry-raising areas, and therefore considerable interest has been attached to a study of its characteristics. During the past year certain circumstances occurred in New Jersey (discussed below), which freshened interest in this disease, and therefore the following brief statement is made in this report concerning the more important phases of bacillary white diarrhea, basing this statement on a summary of bulletin reports issued by those men at the Storrs station who were pioneers in the detection of this organism and the study of the disease:

1. The infection of the chick body with *Bacterium pullorum* is the cause of the disease.
2. The mother hen is the original source of the infection, as the bacilli are present in the ova (yolks) and consequently are included within the body of the chick at hatching time, as infected eggs mean infected chicks. All eggs laid by "carrier" hens are not infected, it seems.
3. The adult hen must have had the disease when a chick, but withstood its effects and matured in spite of the infection, and with development the infection centered in the ovary.
4. Hens thus carrying these organisms in the ovaries are called "carriers" and in the great majority of cases do not show any external symptoms that would indicate the infected condition.
5. The droppings of baby chicks hatching from infected eggs contain the bacteria, and if these droppings come in contact with the food or water consumed by other chicks, or if the droppings are picked at by the healthy chicks, the infection is rapidly spread.
6. Infection with *Bacterium pullorum* usually shows itself within three or four days after hatching, and the highest mortality occurs within the first ten days or two weeks out of the shell.
7. Symptoms developed by chicks infected with this organism vary, but the principal effects are: sticky, whitish discharge, adhering to fluff about the vent, listlessness, sleepiness, loss of appetite, drooping wings, painful cries, and labored breath.
8. Mortality usually very high in infected chick flocks.
9. Infected ovaries of "carrier" hens contain hardened, dark-colored, misshapen ova.
10. It is possible to detect the "carriers" in a flock of breeding hens by making a certain specific blood agglutination test, this technic having been developed by the workers at Storrs, Dr. Rettger and others.

In the spring of 1919 trouble was reported from a New Jersey poultry farm of considerable size, the bulk of which was an exceedingly high mortality in the brooder pens, this often reaching as high a figure as 75 per cent of the chicks in the flock. The average mortality for the entire brooding season was estimated at over 50 per cent. The chicks were reported as hatching well, but developing the marked symptoms of diarrhea at an early age. The best of care and management during the first two weeks in the brooders seemed to be of little avail against the disease. From casual observation of several hundred of these chicks the symptoms seemed to fit very closely the description of symptoms of [illegible]

were not at hand at that time, however, to do the necessary laboratory work to find the organisms in the baby chicks affected. The poultryman was quite naturally discouraged and failed to understand his inability to raise his chicks, as in previous years he had been very successful in his brooding work. Because of the apparent seriousness of the outbreak, and because of a desire on the part of the department to identify the trouble, this case was borne in mind throughout the season, with the idea that an attempt be made, when time, labor and equipment permitted, to test certain of the breeding females in the flocks on this farm by the blood agglutination test, for the detection of possible "carriers."

In the fall of 1919 the poultry pathologist of the department had a conference with Dr. Rettger, at which time the technic of the blood agglutination test for bacillary white diarrhea "carriers" was studied. The necessary equipment, cultures and materials were provided for the making of this test in a limited number of cases. During the winter the poultryman whose chick trouble had been carefully observed, as noted above, was requested to select for testing, 100 of his best breeding hens, which he desired to use during the spring of 1920 for the production of hatching eggs. This request was complied with, and the flock thus selected contained trap-nested birds of high individual value. The following outline of work was completed in connection with this project:

A. Blood samples were taken. Approximately 1.5 cubic centimeters of blood were taken from each bird, these samples being placed in separate test-tubes, each bearing the leg-band number of the individual bird. The blood was drawn from the median vein of the wing. Before it could coagulate the tubes were slanted, thus causing the blood to thicken and coagulate along the side of the tube. The tubes were taken to the laboratory and stored for 24 hours in an icebox, after which time the serum had settled out and collected in the base of the tubes, as a clear, amber-colored liquid. The blood serum is the part used in the test, as it contains the agglutins, if the blood is from a positive case.

B. Cultures of three strains of *Bacterium pullorum* (kindly furnished by Dr. Rettger) were grown on agar slants in sufficient amount for the test.

C. In brief, the theory of this test lies in the assumption that in the blood of "carriers" there are certain anti-bodies present which are formed by the presence in the system of the bacteria, and that when sera containing these agglutins are mixed with suspensions of the specific organisms, a grouping together of the bacteria will take place.

D. In following out the technic necessary to put this theory into practice the following steps were performed:

1. A suspension of a mixed growth of the various strains of *Bacterium pullorum*, 48 hours old, was prepared in a physiological salt solution, to which had been added 0.5 per cent carbolic acid. The strength of this suspension was, to state it practically, to a point of slight turbity. This formed the antigen.
2. For each individual two small test-tubes were set up and properly labeled

3. These tubes were incubated for 24 hours at 137°F., then read, incubated again for 24 hours, then re-read, and then also read again after a further 24 hours at room temperature. In positive cases the agglutination appeared as a sort of white precipitate-like substance, with a definite bunching of bacteria. The negative cases remained cloudy.
4. Any questionable readings were reported as possible positives.

E. A request was made of the owner that the birds reported as positive, or questionable, be sent to the laboratory at New Brunswick for a re-test. Nine birds were found in this group and accordingly sent in. The technic was repeated and the results on the re-test were identical with those of the first test.

F. The next step consisted in requesting permission to perform post-mortem examinations on the nine condemned hens to ascertain if the pathological conditions in the ovaries added further proof to the identity of those hens as "carriers." In every case the ova were dark in color, hard, and misshapen, all characteristic ovaries as described by the investigators at Storrs.

A report was rendered to the poultryman that the certain nine birds had been definitely identified as "carriers." It was recommended that the 91 negative reactors be used as a basic breeding flock for the season of 1920, and that all other breeders be discontinued as such. The owner agreed and the results of the hatching and brooding work on the farm during the past spring were watched with interest.

In a trip made to the farm by the pathologist in middle May, the report was decidedly encouraging, since all traces of the disease had disappeared and no losses from the disease of the previous year had been experienced in the young flocks which numbered several hundred chicks. Very apparently the test did eliminate the "carrier" hens. It is necessary in work of this kind to watch the flock carefully, possibly making re-tests again after a lapse of several months, in order to get any that were not detected at first. The blood agglutination test is not difficult in technic, but does require very close attention to careful, detailed laboratory methods. It requires considerable time to apply the test, but its use is undoubtedly very practical in its benefits to poultry farms infected with this organism.

There are certain points in baby-chick management that should be followed each spring in case there is any suspicion that bacilliary white diarrhea may be present, and even in other cases they will be found helpful. These suggestions are based on the experience of the Storrs station, and that of the New Jersey station during the past few years:

1. Darken the egg chamber of the incubator during the hatch so as to prevent the newly-hatched chicks from picking at the droppings of the other chicks which are deposited on the floor of the egg tray. This also prevents the chicks from crowding to the front of the machine as the hatch progresses. Nature intended the chicks to sleep during the greater part of the time during the first 12 hours outside the shell. A light chamber does not encourage this, but a darkened chamber does.
2. Be sure that the egg chamber and the entire interior of the incubator are well disinfected before each hatch, thus removing any of the *Bacterium*

pullorum that may have accumulated in the machine from infected chicks in the last previous hatch. A 5 per cent solution of any good standard disinfectant can be used for this purpose. It is preferable to apply this disinfectant with a hand sprayer so as to get the material into every part of the interior, for unless the work is complete it is useless. This operation should never be omitted.

. As the chicks are removed from the incubator in readiness to be placed under the brooders, or under the hens as the case may be, it is well to put a small drop of sour skim-milk down the throat of each chick, using a fountain-pen filler or medicine dropper for this purpose. It does not take very long to do this, and it is another good insurance. It gives each chick a taste of sour skim-milk and thus helps teach it to use the sour milk furnished in the fountains in the brooders as soon as they are placed there.

. Place sour skim-milk before the chicks in the brooders during the first two or three weeks, using regulation fountains or pans. The sour milk seems to control the bacteria which infect the digestive tracts of the baby chicks, and the easily digested nutrients in the sour milk gives the chicks a start forward that will help them to overcome the effects of whatever infection may be present.

. Disinfect the brooders in a similar manner to that in which the incubators are cleaned.

. Practice rigid sanitation in all the environments of the baby chicks.

. Feed carefully and manage for continuous growth and development.

. Watch for signs of sickness, removing suspicious cases at once.

t is hoped that this disease has not gotten a serious foothold in New sey, but it is essential that poultry raisers be on the lookout for its earance. Care must be taken by all poultrymen that annually buy stock, new baby chicks, new hatching eggs, and the like, to avoid roducing the infection. Inquiry should be made as to the probable edom of such stock from the germ that causes this trouble. It is roduced into communities from infected areas largely because the rriers" do not show evidence of the infected ovaries which they have eloped. It is usually true that these "carriers" do not lay very much ring the year, this being mainly accomplished during the spring son of heavy production on account of natural stimuli of season, ather conditions and instinct. There are exceptions to this in many es, for in the hundred birds tested, as related above, some of the lividuals were heavy producers and had been for two or three sons.

This is a piece of work in poultry pathology that has proven very eresting, and, it is believed, thoroughly worth while. It is not anpated that any amount of work of this kind will be practiced during coming year, nor can any attempt be made by the department to ke this a general line of departmental endeavor, with the present rking staff and laboratory equipment. It is not considered that the ection is sufficiently widespread in this state to warrant giving this rk precedence to certain other lines that need the immediate attenn of the staff. Circumstances that arise during the year, of course, er plans materially, but it is hoped that bacillary white diarrhea l not tarry long in New Jersey.

Methods of Preparing, Packing and Shipping Poultry and Poultry Products, Together with a Study of Prevailing Prices and Causes of Price Fluctuations of the Greater Markets.

Project Z1-17

The following are the objects of this project:

A. To determine the most efficient methods in broiler production, including the growing and fattening of broilers; the efficiency of shipping alive or dressed; together with a study of seasonal demand and price variation.

B. To determine the most efficient methods of capon production, including the details pertaining to the operation of caponizing; the best methods of growing and fattening; the types and breeds of fowls best adapted for caponizing, together with efficiency methods of dressing and packing; including also seasonal demand and price fluctuation.

C. To determine the most efficient methods of marketing fowls, of the various types and breeds, including methods of dressing and packing, as well as a determination of seasonal demand and price fluctuation.

D. A study of the methods prevailing in the market egg trade, including methods of packing, together with losses from improper handling and packing. A study of sources of supply, together with receipts on the leading egg markets shall be included, and also a study of the various classes of eggs and price fluctuation. A study of cold storage movement of eggs shall be made.

During the last four years, or for the period that the United States was in the World War and up to the present time, there has been a steady increase in the price of nearby white eggs on the New York market. The prices this year are above those of any previous year, and those of each of the past three years have been higher than those of the one before. These prices will undouhtedly continue until the country falls back into its normal economic and business relations.

This increase in the price of nearby white eggs and on all grades of eggs has been brought on by very definite causes. The cost of grains to feed poultry has increased remarkably. The government forbade the use of all wheat that was fit to be milled into flour to be used for animal food of any kind. This restriction took away our one best grain for poultry feed and it made the price of "feed wheat," or the poor unmillable grades, almost prohibitive. Our wheat was sent to Europe and we used other grains as substitutes. But all other grains commanded an abormally high price and it made feeding poultry an expensive operation. Increasing the price of eggs was the only way to meet this feed cost.

The labor problem on all farms has been for the past four years and still is a serious question. The munition plants and factories on war work were paying abnormally high wages, and this resulted in the men and boys from all farming communities, as much from poultry farms as from others, going into factory work. The draft took only a few of the real farmer boys, for the government looked upon farm-

and poultry keeping as a means of national support. But the re-iting offices drew heavily on the boys from the farms. The farm has the real American fighting spirit born in him and many en-ed before the draft, others because they were not accepted in the ft. This was good, patriotic spirit, but it put the man who stayed home ready to do his bit by food production in a hard place. Farm l poultry plant wages had to meet the factory wage for good men, l to do this the price of eggs had to go up.

Table 3

ice Variation per Dozen on State, Pennsylvania and Nearby Western Hennery White Extras

MONTH	1916	1917	1918	1919	1920
	cents	cents	cents	cents	cents
November	68.1	78.6	95.6	99.2	
December	61.6	71.0	95.2	93.1	
January		53.0	73.2	70.4	84.2
February		48.5	61.3	56.3	70.6
March		35.8	45.8	49.0	58.1
April		37.1	40.5	52.0	54.6
May		38.1	41.4	53.5	53.0
June		38.8	48.2	58.0	
July		43.4	53.5	64.0	
August		51.0	63.5	69.5	
September		57.7	65.4	77.0	
October		67.0	83.9	90.2	

During this period the number of eggs on the retail and wholesale markets was redneced. This is because there are not so many birds in the country at present as there were before the war. The food problem which was mentioned above caused many of the farm flocks to be greatly reduced. Many of the suburban flocks and smaller poultry farms were sold out, their birds going for meat and the owners giving up the poultry business because they could not make poultry pay with the high prices of feed and labor. The larger commercial poultry plants in a business-like way overcame the feed problems by feeding new rations and using what was obtainable. But the labor situation handicapped them greatly. They all reduced the number of birds to be taken care of and fed—and this also reduced the number of eggs that went to the market.

The domestic science workers through federal government and state institutions have pushed forward the idea of using eggs as a substitute for red meats, which were being sent overseas in large quantities. Recipes for new dishes containing eggs were published and circulated over the country. These dishes were liked and many found

eggs at their price to be cheaper and more nourishing and satisfying than meat at its extremely high price. The demand for eggs has increased, although the quantity has decreased; and we have the old law of supply and demand operating.

Table 3 shows the monthly average quotation per dozen on State Pennsylvania, and Nearby Western Hennery White Extras on the New York wholesale market from November 1, 1916, to June 1, 1920:

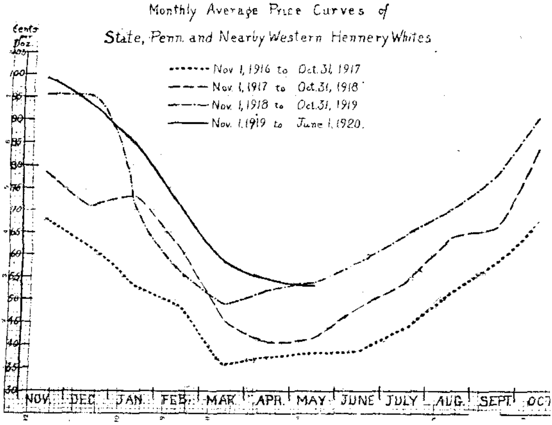

FIG. 2.

MONTHLY AVERAGE PRICE CURVES OF STATE, PENNSYLVANIA AND NEARBY WESTERN HENNERY WHITES, 1916-1920.

The curves in figure 2 show graphically the relation of prices on Nearby White Eggs for the last 3½ years. These curves are plotted from the monthly averages of the daily New York quotations.

External Characters as Indicative of a Fowl's Producing Ability

Project V-A2-19

The following are the objects of this project:

A. To determine a method or methods of accurately measuring a fowl's producing ability by a study of external characters. This study shall include:

1. Measures of past performance.
2. Measures of present performance.
3. Prediction of future performance.

B. To determine the relation of pigmentation to egg production.

C. To determine the relation of body conformation (body type and capacity) to egg production.

D. To determine the relation of detailed minor structural and functional differences to egg production.

E. To develop a system of judging and culling fowls on a basis of their productive ability which shall be capable of practical application to every-day commercial and farm poultry practice.

In the conduct of this project, the poultry department is cooperating in a general way with the departments of poultry husbandry at the Ontario Agricultural College, the Connecticut Agricultural College and Cornell University, to the extent that field conferences are held at these institutions for the mutual comparing of results, for the mutual discussions of their progress made and for the development of new ideas on the project. The studies of pigmentation, body conformation and structural differences which have been discussed in previous reports have been continued. Last fall the conference was held at the Egg-Laying Contest at Vineland, at which there was developed a score-card method of judging fowls for egg production. The following is a report of this conference, together with the score-card developed and the description of its sections:

Score-Card

	Perfection Points	Egg-Production Value
Body type (as seen in coop or on floor)	25	75
Head and adjuncts	15	45
Body conformation (as determined by handling)	30	90
Handling quality	10	30
Legs and toes	5	15
Condition	15	45
Total perfection score	100	300

The above score-card is designed to apply to hens as well as to pullets. In applying the above score-card, the following descriptions of the various sections will aid in a common understanding of the various ideals sought for.

Body Type

Perfect Score—25 Points, 75 Eggs

A bird of good body is usually well-balanced in that the body itself must be deep, showing a nearly rectangular form, well developed in breast and abdomen. Great depth of body is especially desirable. but apparent depth must not be due to loose feathering, which is generally shown by an evidence of loose thigh feathers. Cochin and exhibition game type and feathering are usually associated with poor production. Large capacity is essential if a hen lays long and heavily. Such capacity is designated by a body that is deeper at the rear end of the keel than at the front end. The underline should be fairly straight and the back should be comparatively horizontal. Prominent breast development, with evidence of a long keel are desirable qualities in a high-producing

hen. The general body conformation of a heavy producer conforms very closely to a rectangle with pronounced angles rather than smooth curves. A male shows the same general characteristics as a female except that the abdomen is not so deep.

A small-capacity hen generally stands erect. The body is either very shallow and cut away at the breast and abdomen or in the case of beefy individuals, the abdomen shows a pronounced sagging at the rear of the keel due to large accumulations of fat. Extremely poor producers frequently show a hump on the back.

Head and Adjuncts

Perfect Score—15 Points, 45 Eggs

One of the best indications in picking high layers is the fineness of the head. The head of the heavy producer is fine, showing a lean face, free from wrinkles and overhanging brows. The wattles and ear-lobes fit close to the head and are not loose and flabby. The face is clean cut, the eye is full, round and prominent, especially when seen from the front. An eye which gives a clean-cut, wide-open appearance is desirable. The eyeball of the heavy producer is generally set in the rear of a large oval socket, showing considerable of the white eye membrane in front of the eyeball. The head of a heavy producer should be well-balanced, being moderately deep and broad. The extremely fat, full head of the beefy bird and the long, thin, pointed head of the low-vitality bird are both undesirable and should call for heavy cuts in this section. The low-producing bird generally shows a depressed eye with overhanging eyebrows and wrinkled skin at the back of the eye. The extremely long sharp beak is usually possessed by the low producer, while the medium stout, well-curved beak is characteristic of the high producer.

Body Conformation

Perfect Score—30 Points, 90 Eggs

When taken in the hands, a heavy producer will show, by the sense of touch, great depth of body, especially at the front and rear of the keel bone. The keel must be moderately straight, relatively long and carried well back. The space between the pelvic bones and the keel must be free from excessive accumulations of fat. Birds which are laying heavily can be readily detected by the development of the abdomen. Such birds will show pelvic arches which are wide-spread and a keel which is forced down away from the pelvic arches so as to give large capacity.

The poor producer generally shows a shallow body, especially at the front of the keel, a small shrunken abdomen, together with all evidences of small capacity.

Handling Quality

Perfect Score—10 Points, 30 Eggs

The skin of the heavy-producing hen is thin, soft and pliable, especially the skin on the abdomen must be thin and loose. The skin of the poor producer is generally thick, hard and rather coarse to the touch. The thin velvety skin is almost always associated with heavy ovarian activity.

Legs and Toes

Perfect Score—5 Points, 15 Eggs

The shanks of a heavy producer are flat, pliable and smooth scaled. In hens at the end of their laying year, or pullets which have been laying heavily for some time, the shanks will be bleached out. The toes should be straight and the toe-nails show indication of proper activity. The shanks of the poor producer are usually round and hard, with rather coarse scales.

Condition

Perfect Score—15 Points, 45 Eggs

A bird to be capable of highest sustained production must be first of all healthy. She must show vigor and activity and be well fleshed. Late moulting in hens is desirable. Early moulting and slow maturing, as shown by the primary feathers, should be cut severely. Late developing and late maturing usually indicate low production. In applying this section to hens, health and moulting conditions should be given primary consideration.

Following the conference at Vineland and the evolution of the above score-card the members of the conference went immediately to the Connecticut Agricultural College at Storrs, Connecticut, and spent a day in inspecting, individually and collectively, the birds at the International Egg-Laying Contest, which is being conducted at Storrs. This score-card will be revised from time to time as newer factors are learned and applied.

This concludes the active organized research projects of the department. During the year a number of minor laboratory tests were conducted. They had to do with methods of controlling body lice with sodium fluoride, the use of artificial illumination on brooder chicks, and a test to determine the efficiency of certain by-products which might be used for poultry feeding. Studies have been continued in an effort to determine the sex in baby chicks, and observations are being carried on to improve methods of the home preservation of eggs. The results of these laboratory tests have been published from time to time in press notices, extension circulars and "Hints to Poultrymen."

III. EXTENSION ACTIVITIES

The results of all these research studies would be of little value if it were not for the fact that the department, through the extension division of the State University, is actively dissseminating the results throughout the state, working with the county agents, with the home demonstration agents, with boys' and girls' club leaders, with organizations of poultrymen and through other available channels. The responsibility for putting this work before the poultry keepers of New Jersey is vested in the extension specialist. Many members of the research staff give much time and help to this work. The following is a brief summarized report of the extension activities for the past year, prepared and appended to this report by the extension specialist. For a more complete report of extension activities, see the report of the extension division.

This report includes work from July 1, 1919, to June 30, 1920; however, since the natural fiscal year in poultry begins November 1, and since a great many of the activities of the extension specialist logically begin and close with the natural fiscal year of the poultrymen throughout the state, some of the following report will date back prior to July 1, 1919.

In the past few years a great deal of work has been done and a great deal of interest aroused among the commercial poultry keepers of the state to improve their stock along the lines of increased egg production. A great deal of this interest has been developed by the Egg-Laying and Breeding Contest at Vineland, and to further this plan, a limited number of breeding cockerels which have been bred from individuals of high egg production, have been carefully distributed throughout the state, mostly through the county agents, to those whom it was thought would take the best advantage of breeding stock of this kind, by carefully mating and keeping accurate records.

Without question, the dissemination of the blood of strains of this kind has helped tremendously in improving the egg-producing ability of a great many flocks throughout the state, and although it would be practically impossible to keep an exact record of the entire results of such a project as this one, still, from the reports that have come in during the past two years and from general observations, it certainly is a project which should be continued at least for the near future.

Due in large extent to the efforts of the extension specialist, more modern and approved methods of brooding have been conducted in several sections of the state, where several poultry plants have been erected since the armistice, and where smaller plants have been enlarged. The old system of brooding in long permanent houses has been changed to the system of using coal stoves in colony houses which can be taken from place to place. This has not only reduced the cost of brooding installation, but has greatly increased the efficiency of brooding and of growing better stock.

The culling of flocks or the elimination of inferior individuals, although well demonstrated during the past three years, was continued this year in a more or less general way. Instead of culling the entire flock for certain individuals, these various points were shown at demonstrations on a few birds, in this way making it possible for the extension specialist to demonstrate the matter to more people in less time. A great many poultrymen who had been taught these methods in previous years were used to demonstrate these various points to their neighbors and at local meetings. In this way, undoubtedly, many thousands of inferior birds were eliminated from the flocks and marketed, which was not directly the work of the specialist during the ensuing year, but was the result of work which he had done in demonstrating these methods in previous years.

Improvements in poultry-house construction have been continued throughout the year as in previous years and without question the large majority of the many poultry houses which were constructed in the state during the past year have been built in accordance with plans and specifications as issued by the poultry department through the specialist and the county agents. Also, many old poultry houses and farm buildings were reconstructed or remodeled to include the principles of poultry-house construction advocated by the poultry department.

During the past year in his work on poultry feeding, the specialist not only laid stress on the proper balancing of the various ingredients that went into the rations, but especially on the proper balancing of the amount of scratch feed and mash feed. It has been found that one great fault in the feeding of hens on commercial farms has been that they were fed the same the year around and usually too large a proportion of scratch feed. The use of more mash feed and the use of a regular schedule for the proper balancing of scratch feed and mash feed during different seasons of the year and for flocks of various ages has done a great deal to increase egg production as well as to improve hatches from the eggs from breeding flocks.

During previous years the use of artificial illumination in poultry houses in the state was still more or less in the experimental stage, but as a result of carefully kept records and research projects, a system of artificial illumination of poultry houses has been developed in the state which was generally advised on commercial poultry farms. This has resulted in a large number of poultrymen using this method for increasing their fall and winter production. Probably from 20 to 25 per cent of the commercial poultrymen in intensive centers of poultry production during the past winter used artificial lights for increased winter egg-production with good results. In a great many cases an increase of 100 per cent resulted in production in pens where these lights were used, or in comparing the production with the results of previous years when no lights were used. Poultrymen will use this method in increasing numbers until it probably will be adopted by a large majority of the commercial men in the state.

As a resnlt of demonstrations and advisory work by the extension specialist, a great many poultrymen have used the more improved delousing method with sodium fluoride.

In the central aud southern portions of the state where the soil is rather light, and where it has been difficult for the poultrymen to keep some green food growing in the yard and ranges, special effort has been made by the specialist, with the cooperation of the county agents, to keep a green crop growing in these yards. Alfalfa, rape and soybeans especially have been advocated, and in a great many instances have been used.

The use of acid phosphate on the dropping boards and on the manure pile, in addition to keeping the mannre out of the rain and weather, has resulted in saving a great deal of this asset on many poultry farms, and in greater returns to many poultrymen who have a sufficient amount to sell.

Perhaps the greatest efforts and the most time were spent in a poultry management project which includes a number of commercial poultry farms located in different sections of the state where detailed and complete monthly records were secured. In a great many instances these farms were used as local demonstration plants by various people asking advice on different points of management, such as feeding,

housing, breeding, etc., and it is felt by the specialist that the most efficient work was done through these demonstrations.

Each month the records from these various demonstration plants were received and carefully tabulated. These have furnished a standard of costs and revenues on commercial poultry farms which have been used for instruction to other poultrymen throughout the state.

Caponizing and killing demonstrations have been conducted this year as in previous years with equally good results. There seems to be an increase in demand for the former. Probably a great many more capons will be produced in the state this year than in other years.

The usual number of letters were written by the extension specialist in answer to inquiries on poultry from people in the state. Two circulars—"Hints to Poultrymen," vol. 7, No. 10, and vol. 8, No. 4—were written by the specialist. The specialist was present at the usual number of meetings, which included county community meetings, farmers' institutes and special poultry association meetings. At a great many of these meetings lectures were given illustrated with lantern slides, charts and tables.

IV. PUBLICATIONS

During the year the following publications have been issued by the department: Bulletin 338, Circular 115 and "Hints to Poultrymen," vol. 7, No. 10, to vol. 8, No. 9. The full title of these are given in the report of the director (p. 31).

In concluding this report of research work, it is gratifying to state that with increased appropriations and greater responsibilities due to new legislation, the next year offers a wonderful field for continued activity. The poultry staff appreciate these responsibilities and are entering into the work with their recognized zest and ambition to make the year one of the r
great handicap is the ne
suitable accommodations f
much greater service can
Jersey.

REPORT OF THE DEPARTMENT OF DAIRY HUSBANDRY

Department of Dairy Husbandry

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*Resigned March 1, 1920.
†Appointed March 1, 1920.

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Report of the Department of Dairy Husbandry

William M. Regan

INTRODUCTION

The activities of the Department of Dairy Husbandry for the year ending June 30, 1920, may be listed as follows:

1. *Experimental.* Data have been gathered on five different experimental projects.

2. *Extension.* The Department of Dairy Husbandry, cooperating with the Department of Extension, has given advice and assistance to the dairymen of the state through meetings, correspondence and personal visits. Six separate projects have been carried on. The bull association work and the work of establishing local breeders' clubs has been exceptionally successful.

3. *Advanced registry.* The advanced registry work has developed to such an extent that a great amount of work is required to supervise it efficiently. There has been an increase of 53 per cent in this work over the preceding year. The number of separate tests supervised was 2,152, and 796 records were completed. During the year ending June 30, 1919, 1,366 tests were made and 520 records were completed. There has been a marked increase in the amount of semi-official work.

4. *Glassware and creamery inspection.* The year has seen this work carried on as vigorously as limited funds and the limited authority delegated by the law would permit. Four cases were brought and successfully prosecuted against firms violating provisions of this act. A new law carrying an adequate appropriation and adequate powers for enforcement becomes effective July 1, 1920. It is hoped that this department will be able to render better service to the farmers of New Jersey during the coming year.

DAIRY INVESTIGATIONS

Data have been taken during the past year on the following e perimental projects:

I. Dairy-Cattle Breeding Experiments

These experiments have for their purpose the determination of th method of breeding that will best fix and insure the transmission high production in dairy cattle. In-breeding and line-breeding a being compared with out-crossing.

In comparing the relative efficiency of these various methods the f lowing measurements are being taken:

1. Production:
   - A. Pounds of milk.
   - B. Per cent of fat.
   - C. Pounds of fat per year.
2. Size and Development:
   - A. Body weights taken from birth.
   - B. Height at withers taken monthly from birth.
3. Constitutional Vigor:
   - A. Heart girth measurement taken monthly from birth.
4. Reproduction and Breeding:
   - A. Size and vigor of calves.
   - B. Age at sexual maturity.
   - C. Sterility.
   - D. Susceptibility to abortion.
   - E. Sex ratios.
5. General Conformation:
   - A. Recorded by pictures.

These data have been taken on the foundation animals and on t first generation.

The second generation is now *in utero.*

This experiment is being carried on cooperatively with the Unit States Department of Agriculture, Bureau of Animal Industry, Da Division. The government is supplying the herd bulls to be used the experiment.

II. Normal Growth of Dairy Animals

Body weights and measurements of the height at the withers a being taken on all animals in the dairy herd monthly. The purp is to determine the normal size of the animals of various ages and the different breeds.

III. The Effect of Temperature and Humidity on the Dairy Cow

A. Effect on live weight.
B. Effect on the quantity and composition of milk given.

Data are being accumulated on this project.

IV. The Milking Machine and its Relation to Clean Milk Production

Additional data were collected during the past year on this project.

EXTENSION WORK

Dairy extension work during the past year has been carried out on practically the same lines as during the previous year. The major projects have been cow-testing association work, bull association work, dairy feeding, calf-feeding demonstrations, calf-club work, breeders' associations and state institution work. This work is taken up in *detail in the report of the extension specialist in dairy husbandry* (p. 224-235).

ADVANCED REGISTRY

The following summary shows the amount of work done by this department for the dairy-cattle breeders of New Jersey during the year ending June 30, 1920, and shows a total of 796 records supervised. During the preceding year the number of records supervised totaled 520. This is an increase of 276 records. The preceding year this increase was but 141 records.

Cows tested semi-officially:	
Jersey	147
Guernsey	216
Ayrshire	42
Shorthorn	3
Holstein	89
	497
Number of semi-official tests	2152
7-day records	253
14-day records	4
30-day records	37
60-day records	4
8 months after calving	1
Number of breeders doing semi-official testing	37
Number of breeders doing official testing	37
Total number of breeders doing testing	74
Number of supervisors used for official tests	23
Number of supervisors used for semi-official tests	42

GLASSWARE AND CREAMERY INSPECTION LAW

An act regulating the weighing, sampling and testing of milk and cream when the results of such weighing, sampling and testing are to be used in official inspection or as a matter of public record, or as the basis of payment for milk or cream purchased, and to repeal an act entitled "An act regulating the weighing, testing and purchasing of milk and cream in certain cases," approved March eighth, one thousand nine hundred and sixteen.

The state legislature of New Jersey on March 8, 1916, passed a law regulating the weighing, testing and purchasing of milk and cream in certain cases. This law became effective September 1, 1916, and was enforced with as satisfactory results as could be expected under the means provided therein. Operation of the law brought out its great value to the dairy farmers of the state, as well as many points which, if incorporated therein, would appreciably help in its enforcement and continued benefits. A new law, therefore, was deemed advisable which would incorporate these features and furnish the means for a more efficient enforcement. This new legislation was approved April 5, 1920, and becomes effective July 1, 1920.

The department of dairy husbandry has been entrusted by the director with the station's responsibility in the administration of the creamery inspection and tester's license law. The department of dairy husbandry is directly responsible to the director of the Experiment Station. The chief of the department administers the law through a resident deputy and a field inspector.

The duty of the inspector is to enforce the provisions of the law by supervising the testing where milk or cream is purchased on the butterfat basis; inspecting the equipment of dairy plants; examining applicants at plants for approval as milk and cream samplers; investigating complaints and causing adjustments to be made where violations have been found to exist; gathering evidence relating to any violation of the law, and inspecting and calibrating glassware used for testing milk and cream for butterfat.

The duty of the resident deputy is to enforce the provisions of the law by examining applicants for testers' licenses; issuing licenses to testers; issuing permits to purchasers of milk and cream on the butterfat basis and preparing the evidence relating to any violation of the law and reporting all such violations in behalf of the chief of the department and the director of the Experiment Station to the Attorney-General of the State, whose duty it is to commence proceedings against the person or persons so violating the provisions of this law and to prosecute the offending party to final termination according to the laws of the state.

Complaints, Investigations and Prosecutions

The former creamery inspection law granted no appropriation for carrying out its provisions. As a result, it became quite perfunctory over the period of time between September, 1916, and September, 1918. This laxity of enforcement naturally led to an abuse of the farmers' interests on the part of a few unscrupulous plant managers. Likewise, a general letting down in the efficiency of methods relative to butterfat tests resulted because of the absence of a well-organized system of inspection checks.

In the latter part of 1918, a considerable number of complaints began to come into the Experiment Station from the various county demonstration agents. The farm bureaus had received the complaints from local farmers who had grounds to believe that the creameries were taking undue advantage of them. The urgency of these complaints demanded attention and temporary funds were obtained for investigating conditions in the most representative dairy sections of the state.

The immediate effect of this new inspection brought forth such commendation from the farmers that a more thorough enforcement was planned and put through in 1919. The new law, which carries specific appropriation for its enforcement, will inmeasurably increase the Experiment Station's organization and administration of its provisions.

Prosecutions during the year 1918 and 1919 were made against the following:

Swartswood Creamery Co., Swartswood, N. J. (1918), for not taking the testing samples in accordance with the law. The case was prosecuted by the Attorney General and the defendant fined $100.

Swartswood Creamery Co., Swartswood. N. J.. for underreading of patrons' fat tests (1919). The case was prosecuted by the Attorney General and the defendant fined $200, this being a second offense.

Wm. Provost, Inc., Monroe, N. J., for underreading of patrons' fat tests (1919). The case was prosecuted by the Attorney General and the defendant fined $100.

Janssen Dairy Co., Delaware, N. J., for not taking samples of patrons' milk in accordance with the law (1919). This case was prosecuted by the Attorney General and the defendant fined $100.

Hygienic Milk Co., New Brunswick, N. J., for not taking samples; for testing without a license and for using unofficial glassware (1920). The case was prosecuted by the Attorney General and the defendant fined $100.

In a few other cases conditions and practices were found which did not conform with the provisions of the law. It was pleasing to note, however, that in each instance the creamery concern gave its hearty cooperation in correcting the discrepancies as found.

Glassware Inspection

Beginning July 1, 1920, a new system will be inaugurated whereb jobbers and manufacturers will be permitted to have glassware in spected in large shipments and before it is sold.

In the past the glassware has not been inspected and stamped unti it was sold by the jobber to the consumer and sent to the New Jerse Agricultural Experiment Station for inspection. This method has bee found to be burdensome to the jobber and has been a cause for consic erable delay in shipments, as it was necessary to hold the shipmen after they were billed to the consumer and in most cases statemen for the inspection fee had to be rendered to the recipient of the glas ware. The new arrangement, it is hoped, will eliminate this unneces sary delay. Express and crating charges will be lessened, as the jot bers' orders can be sent direct from the factory to be inspected. Eac box of test bottles, after being inspected, will be sealed and labele with the statement (Inspected Glassware, Department of Dairy Hus bandry, New Jersey Agricultural Experiment Station).

TESTING GLASSWARE INSPECTED (1919-1920).

KIND OF GLASSWARE	Total Number Pieces	Number Incorrect	Per cent Incorrect
Milk test bottles	3068	16	0.52
Cream test bottles	430	1	0.23
Pipettes	282	2	0.71
Total	3780	19	0.502

Each test bottle and pipette found to be correct will be stamped wit the letters S. G. N. J. (Standard Glassware, New Jersey) and a pieces which are incorrect will be returned to the jobber or dispose of as directed. All glassware not conforming to the New Jersey star dard will be promptly returned to the manufacturer or jobber. report showing the number of pieces of glassware received and foun correct will be included with each return shipment together with rendered statement of the inspection fee. The inspection fee will b on the basis of five cents for each piece of glassware. The jobbe or manufacturer will in turn charge the consumer with the same fee.

All testing glassware must conform with the specifications as adop ed by the Official Dairy Instructors' Association, and known as "Stanc ard Babcock Glassware." These specifications are printed in full i Circular 62 of the New Jersey Agricultural Experiment Station.

The amount of testing glassware has increased in the past year over the previous year by 1,822 pieces; the total number inspected being 3,780 for 1919-20 and 1,958 for the year 1918-19. For the year 1917-18 there were tested 1,985 pieces. During 1916-17, the first in which glassware was inspected in New Jersey, 2,454 pieces were tested.

The table on page 148 shows the number of milk and cream test bottles and pipettes inspected and the number and per cent of each which were found incorrect for the past year. Glassware received which was not standard and not inspected, has not been included in the table. Forty-one milk plants sent in glassware for inspection in 1919-20.

Test bottles were first inspected in New Jersey in 1916 when the original law went into effect. It was found on inspection that 7.6 per cent of the glassware sent in was inaccurate. During the second year of inspection 3.87 per cent was inaccurate and in 1918-19 1.7 per cent. The above table shows that during the year past but 0.502 per cent of the glassware inspected was inaccurate. By comparing the figures of the past three years with those of the first year, the results of the enforcement of the inspection law can readily be seen.

The number of tester's licenses issued during the years 1916, 1917, 1918, 1919 and 1920 are shown in the following table:

	1916	1917	1918	1919	1920
Number of persons passing examinations..	34	17	6	16	33
Number of tester's licenses issued........	34	53	23	84	103

During the past year, 48 samples of milk have been tested for butterfat by this department for dairymen of the state. This is a decided falling off in numbers from the 422 samples which were tested in 1918-19. It is believed that this difference is caused by the more efficient administration of the creamery inspection law. Such inspection, it is found, strengthens the confidence of the farmer in the creameryman's test. As a result fewer complaints are received and a much smaller number of samples are sent in to substantiate complaints. Many samples, however, are received purely for informational purposes and the testing of the samples for the dairymen of the state is one of the services which is gladly rendered.

THE DAIRY HERD AND EQUIPMENT

During the past year progress has been made in improving the dairy plant. Adequate pens for test cows and calves have been installed in the dry stock barn. Substantial lot fences have been built adjacent to the barn and platform scales have been installed in the barn for the weighing of experimental animals and feed. Permanent manger divisions have been installed in the milking barn.

A tuberculosis-free accredited herd certificate was issued to the College and Experiment Station dairy herd on February 28, 1920, by the Bureau of Animal Industry of the United States Department of Agriculture. The herd is under the supervision of the government veterinary inspectors and has passed three semi-annual tests without a tuberculosis reaction. The Experiment Station herd was one of the very few herds in the state that at that time had been granted such a certificate. In other respects the health of the herd has been excellent.

Grade "A" raw milk of a very good quality is being produced. The average wholesale price received throughout the year was 13.5 cents per quart, making an income from the sale of milk of $14,271.86. During the first half of the year production was very low, as conditions resulting from the disorganization due to the war were still being felt. During the last half of the year conditions more nearly normal have prevailed and the daily production has averaged 15 quarts per cow.

An inventory of the herd on June 30, 1920, shows a total of 93 animals, 19 grades and 81 pure-breds, distributed as follows:

	Jersey	Holstein	Ayrshire	Guernsey	Milking Shorthorns	Grades
Cows	18	13	9	4	3	17
Heifer calves	6	3	2	3	1	2
Bulls	5	4	2	1	0	
Total	29	20	13	8	4	19

In the above tabulation are included: 1 pure-bred Jersey bull and 1 pure-bred Holstein bull owned by the Dairy Division of the United States Department of Agriculture and loaned to the Experiment Station for the breeding experiment; also a pure-bred Guernsey heifer loaned to the Experiment Station by L. F. Loree for experimental

Mr. Loree also has presented the College with Daffodil of Bowood, an exceptional Guernsey heifer, from the standpoint of both individuality and breeding.

NEEDS OF THE DEPARTMENT

The needs of the department may be summarized as follows:

1. Dairy building adequately equipped.
2. Bull barn.
3. Milk bouse.
4. Workshop and store room at dairy barn.
5. Drainage and leveling of lots at barn.
6. Pasturage.

REPORT OF THE DEPARTMENT OF SEED ANALYSIS

Department of Seed Analysis

*John P. Helyar, M.Sc., *Seed Analyst.*

†Jessie G. Fiske, M.Sc., *Assistant Seed Analyst.*

*Resigned April 1, 1920.
†Became Acting Seed Analyst April 1, 1920.

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Report of the Department of Seed Analysis

Jessie G. Fiske

The Seed Laboratory operating under the seed law has proceeded during the past year along two lines of development; namely, the control of the labeling of seeds relative to purity, germination and weed-seed content offered for sale within the state, and the continuance of the provision for free analysis of samples submitted by farmers and local dealers of the state.

The significance of the law seems quite clear to everyone, even to parties selling seeds in the more remote sections of the state. An awakening of the seedsmen's interest in quality has been observed. A wider cooperative effort on the part of growers and dealers is evidenced by the greater accuracy in the proper labeling and attachment of required statements to seed containers. This is a splendid recommendation of improvement, a spirit which greatly facilitates the operation of the law.

The continual increase in the numbers of samples offered for analysis shows the manner in which the services of the laboratory have been received. Seedsmen and farmers alike are apparently aware of the extremely valuable aid the laboratory gives in a general movement for the betterment of seed distribution.

Publications

Circular 113, Common Thistles, was published during the past fiscal year.

Equipment

A few additions in equipment for the laboratory, which is one of the best fitted seed laboratories in the country, have made it possible to handle a larger number of samples in a more efficient way. The recent purchase of a large hot-air sterilizer enhances the laboratory work not only by rendering more accurate results, but also by helping in the economy of materials used in germination tests.

A microtome has been purchased for sectioning plants sent to the laboratory for identification.

Table 1

Unofficial Samples Tested, 1919-20

	No.	Average *Purity*	Average *Germination*
		per cent	per cent
Grasses and Cereals			
Timothy	49	99.33	89.82
Redtop fancy	10	89.11	84.50
Redtop chaffy	5	51.77	57.10
Rhode Island bent grass	1	81.30	36.00
Orchard grass	14	83.79	70.96
Kentucky bluegrass	19	80.04	51.10
Canada bluegrass	9	85.75	56.16
Fescue species	16	91.78	27.78
Miscellaneous grasses	24		
Grass mixtures	13		
Field corn	59		74.84
Millet	7		89.07
Rye	8		73.00
Barley	1		96.00
Oats	8	99.13	88.56
Leguminous Forage Crops			
Alfalfa	78	96.34	82.80
Alsike clover	51	97.19	83.40
Red clover	53	97.92	92.70
Crimson clover	75	95.98	88.10
White clover	4	96.30	83.12
Sweet clover	8	98.09	67.00
Vetch	42	98.24	64.38
Soybeans	9		63.88
Field peas	6		95.50
Cowpeas	7		61.95
Miscellaneous crops	7		
Miscellaneous Forage Crops			
Buckwheat	2		93.25
Rape	5		92.00
Vegetables			
Asparagus	6		78.66
Beans	120		78.10
Beets	75		100.92 sprouts
Cabbage	55		77.32
Carrot	116		58.80
Cauliflower	3		90.50
Celery	34		55.23
Sweet corn	25		79.96
Corn salad	1		50.00
Cucumber	31		73.38
Dill	4		62.30
Eggplant	19		52.15
Vegetables			
Endive	17		42.88
Kale	4		64.62
Leek	11		68.18
Lettuce	62		68.39
Muskmelon	18		70.80
Onion	65		73.24
Peas	74		82.53
Parsley	11		32.18
Parsnip	9		48.72
Pepper	123		58.08
Pumpkin	2		64.00
Radish	61		80.01

	No.	Average Purity	Average Germination
		per cent	per cent
Vegetables—Continued			
Rutabaga	3		58.33
Salsify	3		78.60
Spinach	43		66.89
Squash	18		66.66
Swiss chard	4		112.70 sprouts
Tomato	77		82.86
Turnip	24		67.85
Watermelon	16		65.21
Flowers			
Nasturtium	11		43.97
Sweet peas	4		91.00
Miscellaneous flowers	107		
Total	1,843		

Unofficial Samples

The analytical work of unofficial samples is, of necessity, the same from year to year. There has been a marked increase in the number of grass and vegetable samples sent to the laboratory for analysis. They have been forwarded, for the most part, by farmers and local dealers who desire information regarding the quality of the seed. These samples cannot serve as any criterion by which to judge the character of the seeds offered for sale within the state at large, because no information is forwarded with them relative to their age or the conditions under which they have been stored. Table 1 gives the number of unofficial samples tested in 1919-20, with the percentage of average purity and germination.

Official Samples

Samples of seeds collected by inspectors are included under this title. The inspection of dealers' stocks has been carried on by Miss Fiske, who has attempted to collect samples from a large portion of the seed offered for sale. Sufficient funds have not been available to permit an inspector to give his undivided attention to the collection of samples. The present status of the department would indicate that the employment of a special inspector is possible. This seems to be the most logical and satisfactory arrangement, as it is upon this work that the enforcement of the law depends.

Plant Identification

There has been a slight increase in the number of plants offered for identification during the past year. A majority of these have

been noxious weeds and in such cases methods of eradication have beei given. The weed situation is a serious problem, and one which shoul be speedily dealt with in experimental study.

Table 2 presents a list for the fiscal year.

Table 2

Identification of Plants

Common Name	*Botanical Name*	*Source*
Redtop	*Agrostis alba*	New Brunswic
Horsetail	*Equisetum arvense*	Trenton
Koellia	*Koellia Virginiana*	Lakehurst
Stingless nettle	*Adicea pumila*	Morristown
Field wound wort	*Stachys arvensis*	Montclair
Trailing bindweed	*Convolvulus repens*	Annandale
Bindweed	*Convolvulus arvensis*	Robbinsville
German knotweed, knawel	*Scleranthus annuus*	Seabright
Lamb's quarters	*Chenopodium album*	Lakehurst
Buffalo berry	*Lepargyraea Canadensis*	Newark
Butterfly pea	*Bradburya Virginiana*	Mays Landing
Spurry	*Spergula arvensis*	Mays Landing
Field cress, pepper grass	*Lepidium compestre*	Zion
Field pepper grass	*Lepidium sp.*	Mt. Holly
Borage	*Borago officinalis*	Metuchen
Rabbit's foot clover	*Trifolium arvense*	Somerville
Rabbit's foot clover	*Trifolium arvense*	New Brunswicl
Yellow sweet clover	*Melilotus officinalis*	Bartley
Narrow-leaved vetch	*Vicia angustifolia*	Closter
Vetch	*Vicia villosa*	Atlantic City
Hemp nettle	*Galeopsis tetrahit*	Lakehurst
Common elder	*Sambucus Canadensis*	Lakehurst
Horse nettle	*Solanum Carolinense*	Union
Horse nettle	*Solanum Carolinense*	Ringoes
Indian chickweed	*Mollugo vertivillata*	Lakehurst
Unicorn plant	*Martynia Louisiana*	Caldwell
Aster	*Aster paniculatus*	Lakehurst
Fleabane	*Erigeron Canadensis*	Lakehurst
Galinsoga	*Galinsoga parviflora*	Sparta
Galinsoga	*Galinsoga parviflora*	Red Bank

Experimental Work

1. THE EFFECT OF AGE ON SEED VIABILITY

This experiment has been carried on for the past three years. Aı attempt has been made to gain information relative to the rate o loss in viability of seeds which have been stored. Samples of gras and clover seeds originally tested in 1913 have been germinated eacl succeeding year. These samples will be retained under the sam laboratory conditions until they are exhausted.

2. STUDIES OF THE GERMINATION OF BEET SEED

This project was started with the idea of determining whether the relative size of beet bolls has anything to do with the number of sprouts and in consequence, the number of seeds produced. This experiment is now under observation and as it was recently started, no definite readings have been obtained.

3. STUDIES OF THE GERMINATION OF CELERY

An attempt is being made to ascertain whether large or small seeds germinate better and whether an aggregate of either in a sample renders the germination high or low. This experiment is being conducted with the above.

4. IMPORTED SEEDS

An interesting study of imported stock of alfalfa and red clover has been made in connection with the laboratory routine work. A special investigation of the weed-seed content of several lots has divulged that six various kinds are of uniform occurrence in imported *samples. These seeds are valuable in identification of lots of imported* clover as they are strictly foreign seeds which, as yet, have not besome indigenous.

Each laboratory test is, in general, an experimental study since the results are obtained in definite percentages of purity and germination. The time which can be devoted to other experiments is of necessity governed by the amount of time consumed in regular analytical work.

REPORT OF THE DIVISION OF EXTENSION IN AGRICULTURE AND HOME ECONOMICS

Division of Extension in Agriculture and Home Economics

Staff

LOUIS A. CLINTON, M.SC., Director.
MRS. FRANK APP, State Home Demonstration Leader.
JOHN W. BARTLETT, B.SC., Specialist, Dairy Husbandry.
M. A. BLAKE, B.SC., Acting State Superintendent and State Leader of Farm Demonstration.
HERBERT R. COX, M.S.A., Specialist, Soil Fertility and Agronomy.
MARJORY EELLS, B.SC., Home Demonstration Agent.
JOSEPH R. FRENCH, B.SC., Assistant Specialist, Fruit Growing.
MRS. CATHARINE GRIEBEL, Home Demonstration Agent.
ELSIE R. HORNE, Asst. State Club Leader.
ARTHUR M. HULBERT, State Leader of Boys' and Girls' Club Work.
M. ETHEL JONES, M.A., Asst. State Club Leader.
WILLIAM F. KNOWLES, A.B., Assistant State Leader of Farm Demonstration.
A. FREEMAN MASON, M.SC., Specialist, Fruit Growing.
INGRID C. NELSON, A.B., Assistant Editor.
CHARLES H. NISSLEY, B.SC., Specialist, Vegetable Growing.
IRVING L. OWEN, B.SC., Specialist, Poultry Husbandry.
STANLEY B. ROBERTS, Assistant Specialist, Dairying.
CARL R. WOODWARD, A.M., Editor.

WILLIAM S. BARNHART, B.SC., Farm Demonstration Agent for Mercer County.
ORLEY G. BOWEN, B.SC., Farm Demonstration Agent for Middlesex County.
MRS. CECILIA BROGAN, Home Demonstration Agent for Paterson.
F. LEON BROWN, B.SC., Farm Demonstration Agent for Sussex County.
LOUIS A. COOLEY, B.SC., Farm Demonstration Agent for Gloucester County.
JOHN C. CRISSEY, B.SC., Farm Demonstration Agent for Salem County.
FRANK B. CROSS, B.SC., Farm Demons tion Agent for Burlington County.
ELLWOOD DOUGLASS, B.SC., Farm Dem stration Agent for Monmouth Cou
BERTEN E. ELY, B.SC., Farm Demonstra Agent for Morris County.
SAMUEL F. FOSTER, B.SC., Farm Demons tion Agent for Camden County.
IRVIN T. FRANCIS, B.SC., Farm Demons tion Agent for Essex County.
HARRY C. HAINES, Farm Demonstrat Agent for Somerset County.
MARGARET H. HARTNETT, Home Demons tion Agent for Passaic County.
CORA A. HOFFMAN, B.SC., Home Demons tion Agent for Morris County.
WILLIAM A. HOUSTON, Farm Demonstrat Agent for Warren County.
E. A. HOWARD, Club Agent for Cumberl County.
HAROLD J. KRAUSE, Club Agent for M mouth County.
EDITH M. RULIFSON, B.SC., Home Dem stration Agent for Mercer County.
MRS. LYDIA GARNAR SALVADOR, Club Ag for Ocean County.
JAMES A. STACKHOUSE, B.SC., Farm Dem stration Agent for Cape May Coun
W. RAYMOND STONE, Farm Demonstrat Agent for Bergen County.
*MRS. GEORGE E. SWAN, B.SC., Home Dem stration Agent for Monmouth County.
JOSEPH B. TURPIN, B.SC., Club Agent Mercer County.
ELTON R. WAGNER, B.SC., County Agent Cumberland County.
ERNEST H. WAITE, Farm Demonstrati Agent for Ocean County.
FRANCES WHITCOMB, B.SC., Home Dem stration Agent for Middlesex County
HAROLD E. WETTYEN, B.SC., Farm Dem stration Agent for Passaic County.
CAROLYN F. WETZEL, Home Demonstrati Agent for Bergen County.

* Died May 26, 1920.

Report of Division of Extension in Agriculture and Home Economics

REPORT OF THE DIRECTOR

L. A. CLINTON

The interesting feature of extension work during the past year has been the change from the war emergency basis to permanent peace basis. During the war funds were made available through appropriations by Congress, and with the use of these funds emergency demonstration agents were employed and placed in several counties of the state and in some of the cities. No effort has been made to continue the city work. The Smith-Lever Act clearly contemplated that the work done under that act should be for rural people, and we have, therefore, devoted our funds almost exclusively to the development of the rural work. The exception to this is in the City of Paterson. Through the interest of the Chamber of Commerce and the schools, an appropriation was secured for cooperation with the extension division in the employment of a city demonstration agent. We have limited our support to that work to $600 per year, the additional funds required being made available through appropriations by the city government.

The county work which was started during the war has all been maintained on a permanent peace basis, and additional counties have come in for cooperation. This addition has without doubt come about through the fact that emergency agents were not placed in counties unless the county gave some financial support to the work. This local support even of an emergency measure resulted in winning the interest of the people of the county to the work, and this interest was so great that the people of the counties themselves desired to maintain the work permanently.

On July 1, 1920, 18 county agents are employed, 8 home demonstration agents and 6 county club leaders, all giving full time to the work, and being employed cooperatively by the United States Department of Agriculture, the State Agricultural College, and the county in which they are located. In all of this work we are recognizing the county board of agriculture as our county-wide cooperating agent. This recognition of the county board does not in any way prevent our cooperating with other associations, such as the grange and farmers' clubs, but in the matter of finance and in submitting the

budget to the county boards of freeholders, the county board of agr culture is recognized as being the official cooperating organization i the support of the work. With the organization of a State Counc of County Boards of Agriculture, and with increased membership i the county boards which will probably result from this state federatio we feel that additional strength will come to the work through th cooperation.

Specialists

Specialists are employed in the following subject-matter lines; dai husbandry, fruit growing, vegetable gardening, poultry, soils an crops, clothing and an additional one will soon be employed in n trition.

Each subject-matter specialist is charged with the responsibili of seeing that extension work in his particular subject-matter is o ganized and carried out in the various counties in the best manner po sible to meet the needs of the people of the state. This is done throug the development of the program of work, this program being worke out in consultation with the county demonstration agents and wit committees representing the people of the county. The specialis work with the county demonstration agents, and give them assistan in organizing and developing their work, and in seeing that the wor as carried out most nearly meets the needs of the various localities.

A plan has been devised by which the specialists may use their pe sonally-owned automobiles in the performance of their official duti and receive compensation for it. This plan has practically doubled th efficiency of the specialists in their work, as it enables them to eco omize on time and reach points in the counties not readily reached b train or by trolley.

Assistants to the specialists have been employed under the dair and fruit-growing projects, and for three months during the summe an assistant is employed in vegetable-gardening work.

Lectures at Farmers' Meetings

The services of members of the extension staff are in frequent de mand for lectures at farmers' meetings of various kinds. During th winter the farmers' institutes under the immediate supervision of th State Department of Agriculture furnish means by which the special ists are able to carry their message to many people of the state. Th policy has been adopted, however, of not accepting invitations to ever meeting, because this would lead to a miscellaneous lot of work whic would be of doubtful value. Many invitations are received for lec tures at meetings where it seems that the purpose is largely by wa of entertainment. All of the members of the extension staff hav their time very fully occupied in the conduct of their outlined progra of work. Invitations are accepted to deliver lectures at meetings only

where it is felt that these meetings will in some way favor the development of the work under the program as outlined. If the meeting is likely to result in something permanent in the way of demonstration work in the community, then an effort is made to render the services desired.

Personal Farm Visits

During the course of the year, a large number of requests are received for members of the extension staff to visit farms throughout the state and advise with reference to the management of those farms. This is a service which the members of the extension staff can perform only in a limited way. While the value of this service is recognized, we believe that the time of the members of our staff should be devoted to work which will result in benefit to a community, and that where farm visits are made, those visits should be in connection with community problems rather than individual problems. Many farm visits are made by the county demonstration agents, and in most cases they are able to render the service desired by the farm owner. Where the problem is beyond the county demonstration agent, and he makes call for the services of the specialist, we are usually able to respond to such calls.

The Extension Service and the Experiment Station

The closest and most cordial relationship exists between the members of the extension staff and the research staff of the Experiment Station. The extension workers must, in a large measure, depend upon the research work of the Experiment Station for the correctness of their subject-matter extended. On the other hand, the members of the Experiment Station staff are kept informed of the problems which are arising throughout the state, and in this way we believe the service rendered is mutual.

The county demonstration agents are called in for conference at the College about four times each year, and at these conferences they meet the members of the Experiment Station staff, discuss with them their problems in the county, and are greatly benefited by the information received.

The farmers of the state who are in need of assistance do not distinguish sharply between members of the extension, Experiment Station or college staff. What they desire is service, and with the close relationship which exists, we believe that this service is being rendered in the largest measure possible.

Finances

Extension work is supported by appropriations made by Congress under the Smith-Lever and supplemental acts, by appropriations from the State Legislature, and by appropriations made by the county boards of freeholders. In a number of counties these funds are sup-

plemented by contributions from individuals or associations witl the county. The discontinuance of the emergency funds which h been made available during the war made it necessary to call upon t counties to increase their appropriation in support of the work. this call every county responded generously, and funds were provic so that all the county work was maintained. The expenditure of t county funds is under the supervision of the extension division of t State Agricultural College. All bills before being paid within t county are first sent to the College for approval either by the sta superintendent of farm demonstration or by the director of extensi Both the state and county appropriations for extension work are ma under authorization by the State Legislature as found in the Laws 1913, Chapter 364, known as the Farm Demonstration Act, and Cha ter 74, Laws of 1918, approved February 16, 1918, an act authorizi the appropriation of money for agricultural extension work and t promotion of home economics.

Staff Changes

Appointments

Date	Employees	Title
Sept. 1, 1919	Lydia G. Salvador, Ocean	County Club Leader.
Sept. 8, 1919	Cecilia B. Brogan, Paterson	Home Demonstration Age
Oct. 8, 1919	Wm. S. Barnhart, Mercer	County Agricultural Agen
Nov. 5, 1919	Orley G. Bowen, Middlesex	County Agricultural Agen
Nov. 7, 1919	Stanley B. Roberts	Assistant Specialist in Dai Husbandry.
Nov. 24, 1919	John C. Crissey, Salem	County Agricultural Agen
Jan. 12, 1920	Elton R. Wagner, Cumberland	County Agricultural Agen
Jan. 26, 1920	Harold S. Ward, Morris	County Club Leader.
Feb. 16, 1920	Ernest A. Howard, Cumberland	County Club Leader.
Feb. 16, 1920	Irving L. Owen	Specialist in Poultry Hus bandry.
Mar. 15, 1920	Joseph R. French	Assistant Specialist in Fr Growing.
Mar. 16, 1920	Francis M. Whitcomb, Middlesex	Home Demonstration Age
Mar. 20, 1920	Samuel F. Foster, Camden	County Agricultural Agent
Mar. 22, 1920	F. Leon Brown, Sussex	County Agricultural Agent
Mar. 30, 1920	Edith M. Rulifson, Mercer	Home Demonstration Agen
April 5, 1920	Elsie R. Horne	Assistant State Club Lead
April 5, 1920	Harold J. Krause, Monmouth	County Club Leader.
May 3, 1920	Frank B. Cross, Burlington	County Agricultural Agent
June 1, 1920	B. Eugenie Huckel, Essex	Home Demonstration Agen
June 2, 1920	M. Robert Trimnell	Assistant County Agent.
June 21, 1920	Howard Mason, Warren	County Club Leader.
June 23, 1920	Amos Howard Saxe	Assistant County Agent.

Transfers

Date	Employee
Oct. 6, 1919	Berten E. Ely became County Agent of Morris County instea of County Club Leader of Essex County.
Jan. 1, 1920	Wm. F. Knowles became Assistant State County Agent Lead instead of Assistant State Club Leader.
April 1, 1920	Herbert R. Cox became Specialist in Agronomy instead c County Agent of Camden County.

REPORT OF THE STATE LEADER OF FARM DEMONSTRATION

M. A. BLAKE

History

A brief history of the development of farm demonstration work in the various counties of the state from 1912 to June, 1919, inclusive, was published in the annual report for 1919, and the present report will bring this to July 1, 1920.

The past year has been a period of readjustment in farm demonstration work as well as in other lines of effort. During the war the number of county agents and assistants was greatly increased through the emergency appropriation. The return of the country to a peace basis could be expected to bring about changes, especially in such a new and enlarged field as extension work.

In New Jersey one of the leading problems of the past year has been to make permanent the work of the county bureaus and to keep them supplied with efficient agents. From September 15, 1919, to July 1, 1920, there were eight changes in county agents, or a turn-over of more than 40 per cent.

The transfers and appointments are given in the report of the director (p. 166).

Fortunately, it has been possible to fill all of the vacancies fairly promptly and the new men have shown exceptional ability in getting into touch with the county work and carrying it forward.

At one time during the war period 3,145 county agents were employed in the United States, but this had been reduced by June 1, 1920, to 2,353, or a loss of practically 43 per cent. New Jersey had a total of 17 county agents during the war, and on June 1, 1920, a total of 18 with two assistant agents engaged to begin work July 1.

Howard F. Huber resigned as assistant state leader December 15, 1919, to engage in commercial work at Seabrook Farms, Bridgeton, N. J., and he was succeeded by William F. Knowles, January 1, 1920.

State Council of County Boards of Agriculture

On the evening of July 10, during the summer tour of the New Jersey State Horticultural Society, a meeting was called of representatives of county boards of agriculture at Hotel Albermarle, at Asbury Park, to consider the question of a State Council of County Boards. Earle Dilatush, of Robbinsville, acted as chairman, and following a discussion a committee was appointed to take up the question in more detail with the various counties and to call a later

The second meeting was held at Trenton, September 6, with representatives from 12 counties present. A tentative constitution and by-laws was presented which called for the election of temporary officers and a temporary executive committee of 15 members.

The following men were elected to fill these positions:

President, H. E. Taylor.
Vice-President, Arthur Lozier.
General Secretary, John H. Hankinson.
Treasurer, Joseph Barton.

Executive Committee.

Camden—H. H. Bell.
Bergen—Wm. H. Bomm.
Cape May—Joseph Camp.
Mercer—Earle Dilatush.
Passaic—George L. Fisher.
Cumberland—H. H. Hancock.
Gloucester—A. R. Kohler.
Bergen—D. Y. Lewis.
Burlington—Edward E. Logan.
Ocean—H. H. Ober.
Middlesex—D. J. Perrine.
Sussex—Theo. M. Roe.
Atlantic—W. P. Thompson.
Monmouth—E. W. Winsor.
Somerset—W. H. Whiton.

The formal organization of the State Council of County Boards of Agriculture took place in Trenton, January 15. Representatives from 14 counties were present at this meeting. The temporary officers chosen at the meeting of September 6 were made permanent officers and the tentative constitution and by-laws was amended so that the executive committee would be composed of 2 delegates from each county board of agriculture.

Extension Conferences and Auto Tours

Two auto tours were conducted during the season of 1919 for the purpose of making field studies of demonstrations. The first was run from July 31 to August 2 and covered points in Cape May, Atlantic and Cumberland counties.

The tours gave the agents an opportunity to see how a few of their number were actually carrying out extension projects in the field.

October Conference

The fall conference was held from October 15 to 17, 1919. The principal feature of the first day's program was a review of the season according to distinct lines of work, such as dairy, soil fertility and vegetables, with the idea of bringing out helpful facts and [illegible]tions

A dinner was held at Winant's Hall the first night, following which Dr. J. G. Lipman related experiences of his trip to Europe.

The third day was given over to reports by various heads of subject-matter departments upon results of experiments and investigations.

February Conference

The February conference was scheduled for the fifth, sixth and seventh, and was held in spite of a severe snow storm which began during the night of the fourth and completely tied up traffic on some lines of railroad. A method of classification of project aims was presented to the agents and the details of outlining a project. Committees comprised of agents and specialists were appointed who classified the project aims in the new way in each county.

March Conference

The unfavorable weather interfered with the prompt attendance of the agents at the February conference, so another was held March 29 to 31. Paid membership in county boards of agriculture was the topic of the first session. County Agent Green, of Orange County, New York, discussed how membership campaigns were conducted in his county. Following a general discussion John H. Hankinson spoke briefly on the work and aims of the State Council.

The morning of the second day was largely occupied by discussions on systems of keeping field and office records and methods of filing.

A committee consisting of the state leader, Mr. Douglass and Mr. Wettyen was appointed to revise the weekly report blank to conform with the monthly report sent to Washington and to include the listing of practicums and miscellaneous visits. One session also was devoted to a discussion of community programs of work and "how can community leaders be encouraged and trained?"

June Conference

A special meeting of the county agents was held from 10 to 11 a. m., on June 17, during the field meeting at the College Farm. The state leader made a report of a special state leader's conference in Washington, and made come suggestions on the improvement of annual reports. It was voted that a summer conference be held at the college during August instead of an auto tour in the counties.

Joint Conference of State Council of County Boards of Agriculture and Extension Division

On the evening of June 17 representatives of county boards of Agriculture and extension workers met in Ballantine Gymnasium. Reports were made by the leaders in club, home demonstration and farm demonstration work. This was followed by a detailed discussion upon developing community and county consciousness and leadership, by Mr Howard McConnell, of Atlantic County, and Mrs. Wm. Brubaker, of Passaic County.

Planning, Outlining and Classifying Aims of Crop Projects

Although the matter was first presented to the county agents in February, 1918, it was during the fall and winter of 1918-19 that special emphasis at extension conferences was placed upon the necessity of considering farm crops in each county on a county and state-wide basis, and the drawing up of programs of work and outlines for the same that would meet the county needs in a large way.

For example, it was made plain that before deciding as to just what extension work should be done with corn in any county, it is important to determine the status of corn as an agricultural crop both in the county and in the state. Having determined the status, the future of the crop and its problems are brought before us. We are then in a position to decide what problems might be attacked in community programs and which should be county-wide endeavors. A broad analysis of the status of a crop should thus enable a county so to direct and correlate its community and county work as to accomplish the most possible and largely to eliminate waste effort.

Considerable time was devoted to drawing up project outlines as examples for agents to follow. Many agents were able almost immediately to determine and write up the status of the more important *crops in their counties. In some instances groups of growers were* called into conference meetings, since accurate data were not available in any other form. Two actual examples of how the crop status was written up for the county project follow:

Potato Improvement in Salem County

Status

1. Number of farms in county	2,400
2. Number of farmers raising potatoes	900

5. *Relative importance of Crop.* The potato crop in Salem County ranks among the first in importance. There is a large acreage and the industry is spread throughout the county, wherever it has been found that white potatoes will grow successfully. The center about Daretown and Woodstown is known as the Garden Spot of South Jersey and here potatoes are the principal money crop. Perhaps next to Monmouth County, Salem is the most important potato county in the state.

6. *Varieties and Type.* The potatoes grown are chiefly of the Irish Cobbler variety. A very few Superb and Green Mountain and Red Skins are grown, and a few growers are starting on Giants, but perhaps 95 per cent of the potatoes grown are Cobblers.

It is also a general practice to grow second-crop Cobblers for immature seed. Nearly all the county's seed is raised in this way and some is sold outside the county and state.

Three men in the county have attempted to improve seed by growing certified seed.

7. *Cultural Methods.* In most cases, barnyard or stable manure has been used as the heavy fertilizer in general upkeep of the soil. This manure is put on as drawn out during fall and winter months, and applied at the rate of about 10 tons per acre.

The ground is usually plowed and prepared around the middle of March so as to get potatoes in before April first. It has been the custom generally to use a standard fertilizer in the county, usually a 4-8-4 or 4-8-5, depending on the time when it can be procured and the price.

8. *Marketing.* Potatoes, as a rule, are sold through local agencies, such as the South Jersey Farmers' Exchange—which organization was first formed to market the potatoes of Salem County—and through individual buyers and dealers. Some are shipped to the Philadelphia, New York and Baltimore markets, while some are kept in local and commercial storage houses.

Very little growing on contract has been done. The dealers buy at a price considerably below the market at times, showing that market conditions could be improved by organization.

9. *Diseases.* The most destructive disease is potato scab, which has developed to an alarming extent only in the past two years.

Rhizoctonia is quite prevalent and late blight is more or less prevalent.

10. *Seed Selection and Storage.* Many growers still depend on Maine (Eastern) seed, but are gradually coming to realize the superiority of home-grown second-croppers.

Home-grown seed is stored in local storage houses mainly a home storage. Eastern seed is bought in the winter and delivered before planting time. Seed for the second crop is kept in storage.

Dairy Improvement in Sussex County

Status.

1. Number of farms, census 1910	2,600
2. Number of farmers engaged in dairying	900
3. Average acreage of farms	157 acres
4. Average number of cows per farm	25

5. *Importance of Industry.* Sussex County, because of its topography, is naturally adapted for dairying and consequently we find 90 to 95 per cent of the farmers are dependent upon the dairy industry for their livelihood. This county is by far the leading dairy county of the state and in respect to its size, produces more milk than any other county of the same area in the United States. In 1917 the average production per cow recorded from the herds books of the cow-testing associations in the county was higher than that of any other association in the United States. According to farm management surveys this county is one of the most if not the most intensive dairying section in the United States.

6. *Types and Breeds of Cows.* Most of the dairy stock are grade Holsteins; there are, however, many pure-bred cows in the county. There are also some breeders of pure-bred stock; among them Tranquility Farms at Tranquility, I. N. Avery at Sparta, Brookdale Farm owned by Irving N. Roe at Branchville, George Lewis at Stillwater, Bonny Brook Farm at Stillwater and Belle Ellen Stock Farms at Sussex and Beemerville. At least 75 per cent of the dairymen have pure-bred herd sires. Over 90 per cent of the dairy stock of the county are Holsteins with a scattering of Jerseys, including one breeder of pure-bred Jerseys. There are a few grade Guernseys and one herd of Dutch-Belted cattle.

7. *Type of Dairying.* About 90 per cent of the dairy herds in the county have been built by the raising of youug stock on the farms. Practically every farmer raises calves to keep his herd normal in number, by replacing older cows and animals lost by disease or sold. A few farmers practice selling young stock as a cash proposition, especially those engaged in breeding pure-breds. There are pastures on practically every farm, but because of the rolling nature of the land they do not furnish green pasture throughout the dry season. There is a tendency toward supplementing these pastures with a grain ration throughout the summer, and a few dairymen of this county do not pasture at all. There are a very few practicing summer silage feeding and practically none use soiling crops.

8. *Method of Feeding.* Clover and mixed hay are fed by most of the dairy farmers as the principal ronghage, corn stover ranks next and is used on practically every farm. Some farmers shred the stover and use stalks as bedding. Oat-straw is used as a roughage in some cases, although alfalfa can be grown on practically every farm and is used as roughage by few farmers, the great majority of dairymen not having learned its value as a cheap and economical milk producer and consequently we find but little grown on the farms.

Silage is considered essential in the dairy ration by about 50 per cent of the farmers, although there are many dairymen who do not have silos. The silage *consists mostly of corn, practically no soybeans or field peas are grown for this* purpose.

Most of the corn grown in the county is for silage purposes; less than 50 per cent of the dairymen have enough corn available for cob meal in the ration. Many acres of oats are grown in the county, but most farmers sell them as cash propositions.

These are by far the principal grain crops of the county and other feeds have to be bought to balance the ration. The feeds mostly bought by the dairymen are linseed and cottonseed meal, Brewers' grains, gluten, beet pulp and a vast amount of mixed and proprietary feeds. Some of these feeds are of the poorer quality and consequently a poor investment for the dairy farmer.

Most of the calves are started on milk and finished off on calf meals. There are a few farmers, however, who use a home-mixed calf meal recommended by the Experiment Station. Young stock are kept chiefly on roughage.

Very few farmers are feeding a balanced ration strictly in accordance with the milk production. Cow-testing association work, however, has proved to its members the value of intelligent feeding and most of the dairymen are feeding balanced rations who are members of the cow-testing association.

9. *Marketing.* Practically all the producers sell their products as market milk to New York City, through the many and various creameries throughout the county. The majority of these creameries are owned by New York City syndicates. There are several farmer-owned creameries but they are not run on a cooperative basis. Most of the milk is sold on a butterfat basis, through the Dairy League, which acts as the dairymen's sales agent. No butter or cheese is manufactured in the county on a commercial scale. Some proprietors of the smaller creameries in the county have been very unfair in giving honest butterfat contents of their milk. Many thousands of dollars have been lost to the dairymen as a result. In the past there has been considerable misunderstand-

which has resulted in two very serious and extended milk strikes. In both of these cases, however, the farmers' organization has received the price asked for their production, this price being based on the cost of production.

Very little tuberculin-testing has been done in Sussex County. The New York Board of Health, however, sends inspectors and veterinarians who inspect sanitary conditions of the barns and make physical examinations of the cows which supply the New York market with milk. There have been some outbreaks of contagious abortion, but none that has assumed serious proportions.

Tuberculin-testing should have more attention, also the control and prevention of contagious abortion. Scours among calves are quite prevalent. White scours has oftentimes prevented dairymen from raising a silage calf during a season.

Classification of Project Aims

The work done in connection with any crop project may vary greatly in character. For example, a project "to improve the apple industry of * * * county" may have as its aims for one year demonstration orchards, pruning, spraying, cooperative purchase of sprayers and fruit exhibits. Pruning and spraying under a project may take the form of special work conducted throughout the season by a specialist; or it may he simply the holding of meetings at various points when some practical features are illustrated. It may even consist of simply a publicity campaign to encourage a considerable number of growers to adopt a recommended practice. It is therefore desirable in outlining a program of work for a county that we have a method for classifying these various forms of activity.

At the extension conference held at New Brunswick, February 5, 6 and 7, the following method of classification was presented to the county agents for consideration and trial:

1. *Demonstrations.* A farm demonstration is the accomplishment of certain definite results in farm practice through the employment of established principles and methods. It involves the keeping of records which will clearly show the value of the methods demonstrated and the presentation of such records at community and county-wide meetings. It is a piece of work for which the county agent assumes the responsibility for its conduct individually or in cooperation with a specialist. A demonstration will often serve as the basis for the other project aims.

2. *Practicums.* A practicum is the showing to a group of people of a method of doing a thing or the making of a comparison of the efficiency of different kinds and makes of machinery, tools and appliances.

It differs from a demonstration in that it does not include the securing of records and the usual "follow up" and publicity. The term "practicum" may not be the best which can be chosen to identify this form of endeavor. It is further suggested that in advertising a practicum it might be called a "practice" which it really is if those in attendance are encouraged to take part, as should often he the case.

3. *Organization.* There are certain features of extension work in connection with any farm crop or product which are developed or promoted through the organization of the producers. This is distinct from organization work in connection with the county board of agriculture which is outlined as a separate project.

4. *Campaign.* A campaign is a systematic organized attempt to increase the acreage or the production of a farm product; the more general adoption of

a practice or a method, the increased use of an appliance; or, in general, it is a community or county-wide effort to accomplish a specific purpose within a limited time through publicity, personal solicitation and otherwise.

5. *Advisory Enterprises.* An advisory enterprise is the furnishing of a plan or systematic advice to one or more individuals who agree to follow the recommendations given. The county agent assumes responsibility for the plan or advice given, but not for the success or failure of the enterprise.

Advisory General. A county agent may also give special attention to some feature of a project in the form of publicity in news letter and press which is not in the nature of a campaign or an advisory enterprise, but which promotes and looks toward the development of interest in some feature of the project work in the county.

6. *Exhibits.* Community, county and state-wide exhibits are often a valuable means of promoting the development of an industry and the organization of the people, and may be made a feature of project work.

7. *Cooperative Investigational or Control Work.* County agents cooperate with such state agencies as the Agricultural Experiment Station and State Department of Agriculture in assisting them to locate and start pieces of investigational or control work within the county and in promoting their progress and success through publicity in news letter and press and through the county board organization.

Such activities should be credited to the county agent but should not be listed or reported as demonstration work.

The county agent will in no case assume responsibility for the success of this work.

8. *Miscellaneous.* There may be other activities in connection with a project which cannot be readily classified under the heads submitted. If so, these may be listed under *miscellaneous.*

As an illustration of how a classification of project aims may be employed we may take the project "Improvement and Development of the Apple Industry of ———— County."

Project Aims for 1920.

1. Demonstrations:
   - 2 demonstration orchards.
2. Practicums:
   - 3 pruning.
   - 4 spraying.
   - 3 packing.
3. Organization:
   - Cooperative purchase of apple barrels.
4. Campaigns:
   - 9 power sprayers in the county in 1920.
5. Advisory work:
   - Enterprises, 9 cooperative orchards.
   - General, special publicity on better spraying.
6. Cooperative investigational or control work:
   - a. With State Bureau of Markets.
     - Obtaining cooperators for crop statistics.
   - b. With State Experiment Station.
     - Notes of prevalence of fruit diseases.
     - Cooperator for potash experiment.

Statistical Record of Certain Farm Demonstration Office Activities

A record of the number of farm visits made by an agent or the number of letters written is not a true measure of an agent's value to a county. It is what he accomplishes in those visits and the quality of

the information furnished in the letters that counts. A record of this sort is of considerable value, however. Some counties show a considerable number of office calls. This means that relatively more time must be given to meeting such demands in those counties. It suggests, too, that such an office should be well supplied with information in an available form and that the work should be so organized that the clerk and stenographer can meet a portion of the requests.

Table 1

Statistical Summary of Special Activities
December 1, 1918, to November 30, 1919

County	Office Calls	Farm Visits	Demonstration Visits	Meetings at Demonstrations	Attendance	Other Meetings	Attendance	Letters Written	Circular Letters Mailed
Atlantic	359	1775	764	65	1012	72	2109	3248	17646
Bergen	410	846	103	7	428	87	3010	1047	4239
Burlington .	692	695	62	6	82	5	3207	963	5698
Camden	884	728	292	2	21	55	865	2288	17296
Cape May .	128	761	112	21	224	46	1943	1782	11201
Cumberland	1001	847	223	2	26	89	5852	1921	10710
Essex	2081	829	180	5	155	76	2358	2116	25081
Gloucester .	725	430	107	5	85	41	1883	1600	16074
Mercer	324	705	115	3	210	96	4373	875	1350
Middlesex ..	570	544	87	3	224	70	2889	1109	6790
Monmouth .	1150	580	151	3	165	78	3989	2000	15801
Morris	1227	386	84	4	674	87	3524	3331	11787
Ocean	302	920	54	4	45	38	3105	930	4095
Passaic	685	855	273	8	169	94	2511	1560	10061
Salem	289	676	100	4	100	33	1890	709	7064
Somerset ..	577	634	195	3	27	46	1351	1203	5421
Sussex	2146	1172	83	11	191	89	14234	2743	23249
Warren	834	474	38	12	2754	36	1993	1487	18222
Total	14384	13857	3023	168	6592	1138	61086	30912	211875

While the size of farms and the ease of traveling vary greatly in the different counties, still a record of the number of farm visits gives one some idea of the contacts an agent makes with individual farmers. The number of meetings held, with the attendance, is an indication of the interest and activity shown by the people in the county. A record of the number of letters written is a measnre of the amount of correspondence which a farm demonstration office is obliged to handle.

These examples illustrate the value of such statistics. The weekly report blank in use up to July 1, 1920, did not properly classify the various kinds of meetings, and the number of meetings at demonstrations is probably too low. They have in too many cases been listed as "other" meetings.

Table 2

Statistical Summary of Special Activities January 1, 1920, to July 1, 1920

County	Office Calls	Farm Visits	Demonstration Visits	Meetings at Demonstrations	Attendance	Other Meetings	Attendance	Letters Written	Circular Letters Mailed
Atlantic	306	890	204	2	45	48	1230	2368	21070
Bergen	210	395	53	22	689	62	2540	803	3818
Burlington .	397	126	62	2	30	24	1396	302	2983
Camden	468	313	126	4	82	33	1084	1017	8282
Cape May ..	192	611	72	1	9	38	1053	1721	4300
Cumberland .	384	442	95	....	......	52	2299	758	8224
Essex	585	308	18	1	55	34	2268	875	16235
Gloucester ..	369	237	24	1	3	39	1330	676	22681
Mercer	222	341	37	....	......	48	1407	297	12826
Middlesex ..	324	358	42	2	20	30	1054	1126	7520
Monmouth ..	782	245	118	1	400	29	1363	1776	7482
Morris	842	490	77	3	79	56	1838	1054	12811
Ocean	394	569	95	....	......	30	1077	1162	4508
Passaic	676	447	122	....	......	55	2299	1010	6097
Salem	432	777	90	1	21	207	1848	519	5205
Somerset ...	413	339	61	....	......	31	855	883	4311
Sussex	865	314	46	27	906	38	5334	1204	7778
Warren	795	334	77	17	109	45	1955	1187	13632
Total	8656	7536	1419	84	2448	899	32230	18738	169763

The summary here published is for the period from December 1, 1918, to November 30, 1919. This is the basis on which all state summaries are made up for the Washington office of the States Relation Service. A summary from July 1 to June 30, or on the basis of the state fiscal year, is of little value in making comparisons between states, thus the use of the standard method. A second table, giving a statistical summary of the work from January 1, 1920, to June 26, 192

The Evolution of the Service Rendered by a Farm Demonstration Office

When farm demonstration work was first established in the counties, the field of endeavor was relatively limited, as would be expected, since every new undertaking requires time for development. In 1912 there were no trained county agents. There was little experience on which to base plans and methods of procedure. Community and county organization was yet to be developed. The entire structure had to be added to and rearranged as the work progressed.

A large proportion of the farmers had the idea at first that the principal duty of a county agent was to go about and tell individual farmers how to farm. A considerable number of people to-day, especially among those who are taking up farming for the first time, or who have purchased small country places, have the idea that the duty of the county agent is to show them how to prune their single cherry tree or their half dozen currant bushes, or to tell them what is the matter with a sick hen. They do not realize that in order to promote the production of food and the welfare of agriculture in a county, the agent must work in a larger way and to a considerable measure with groups of individuals.

New Jersey has a diversified agriculture, and it is common to find at least four distinct lines extensively developed in a county, such as *dairy, fruit, farm crops* and *poultry; frequently certain farm crops* such as potatoes are almost an industry in themselves, and this is equally true of tomatoes among vegetables. All of these may rightfully demand their share of attention and service.

When first established the county offices were greatly handicapped to do large pieces of work. Several so-called extension specialists at the college rendered some assistance to the counties; Agricultural Experiment Station and College investigators and State Department of Agriculture officials did their part, but there were only few county leaders. The whole had not been organized into a great service machine, county agent offices were not adequately equipped, and the work was new to stenographers and clerks.

Types of Service Rendered

The service now demanded of a farm demonstration office in a progressive, agricultural county is extensive and varied.

It first serves as a bureau of information to which agricultural inquiries of all sorts are referred; inquiries as to sources of good seed, plant-foods, farm snpplies, labor-saving implements and machinery, inquiries as to fertilizer and spray formulas and schedules, inquiries as to complex plant and animal troubles and how the assistance of state and national experts may be obtained, inquiries as to standards and

laws affecting agricultural products and others too numerous to mention. These inquiries come in by telephone, by letter and in the form of office calls.

To meet this demand a well-organized office must have a considerable fund of readily available information on file. The county agent is obliged to spend a large part of his time in the field and he should have an efficient office assistant and stenographer who can meet some of the requests through the distribution of circulars and prepared plans and directions.

A second function of the farm demonstration office is the administration and direction of the county program of work. This is now becoming its most important feature.

A county program of work includes activities that concern single communities and others that are county-wide. A community project may be such an activity as the cooperative purchase of a carload of certified seed potatoes, the establishment of a cooperative limestone plant, or the securing of better shipping facilities. A community program may commonly be made up of several such projects and if there are from 12 to 24 communities in a county the sum total of such work may be considerable. The local people are expected largely to manage and carry out the details of such a program but the farm demonstration office is looked to for leadership and direction.

Every county includes activities in its program of work which may be called special demonstrations, such as soil sterilization of seed-beds to destroy lettuce diseases, which mean the difference between hot-beds filled with lettuce plants or bare frames. In the beginning such a demonstration calls for the assistance of a trained specialist who knows just how the work should be done. The farm demonstration office arranges for the cooperation of such specialists and for the carrying out of the whole project.

In some counties of the state serious animal diseases, such as hog cholera, are prevalent, and while a certain number of state veterinarians are available to inoculate hogs, the volume of work now accomplished is due in a large measure to community organization and to the assistance rendered by the county agent in planning and assisting the veterinarians to carry out a schedule of work.

Every little while a new plant disease or insect trouble appears, or an old trouble assumes a new form. The watchful county agent immediately gets in touch with the Experiment Station and soon has an expert on the spot. An example of this was the outbreak of the clover worm which attacked lima and snap beans so seriously in 1919. Only prompt measures were of any avail in preventing serious damage, and it was for the farm demonstration office to reach the farmers of the county with warnings and remedies.

In all such emergencies the office is besieged with inquiries as to where poisons, spraying implements and machinery can be secured at short notice.

In addition to work of the types mentioned the farm demonstration ffice is expected to issue a monthly news letter, assist in securing crop eports, plant disease surveys and many similar things.

The county agent must also encourage and take part in various com- munity and county meetings and cooperate with such organizations s the grange. He must attend a certain number of state meetings in rder to keep himself informed as to state policies and progress. The rork of the farm demonstration office has now developed to such di- nensions that it becomes clearly evident that its main problem is so to ystematize and direct all of the activities that available assistance nd equipment is used to the best advantage and with a minimum of raste effort.

REPORT OF HOME DEMONSTRATION WORK

Mrs. Helen M. App, *State Leader*

Home demonstration work has made great progress in all the counties where the work is being carried on intensively. This year showed the final adjustment of the work from the war-time basis to a permanent footing. Community and county committees are assuming responsibility for the development of the work in their sections and are assisting the home demonstration agents in putting over the programs of work. These programs are made up in the counties and are based upon the requests and needs of the people in the communities.

The work in Middlesex County was temporarily discontinued on June 30, 1919, but at the request of the freeholders, in December, a new agent was appointed and the work again started on March 16, 1920. Miss Frances M. Whitcomb was selected for this position.

Mercer County was without an agent from August 30, 1919, when Miss James resigned, until April 1. The new agent, Miss Edith M. Rulifson, was not appointed until the people in the county felt the actual need for a home demonstration agent.

The women of Essex County became so interested at the annual county board meeting in the work of the home demonstration agent that they requested the freeholders to make an appropriation for this work for the year 1920. Miss B. Eugenie Huckel was appointed and began her work in that county Jnne 1, 1920.

The people of Paterson accepted Mrs. Cecilia B. Brogan for their home demonstration agent September 16, 1919. This is the only city where we are carrying on home demonstration work and the work is generously supported by the city and the Chamber of Commerce.

Sussex County has had a great deal of miscellaneous work in its communities, and in June the county board of agriculture accepted the proposition which was made them by the director of extension and they selected Miss Marjory A. Eells for their agent. Miss Eells will begin work in Sussex County on July 1.

A permanent home demonstration program seems to be developing according to the various projects.

The food work has been carried on up to this time by meeting the requests for demonstrations and lectures pertaining to this subject. These have been conducted according to the desires of the women. In some places schools have been held where various phases of cookery have been studied, the women themselves conducting the demonstrations. This is, we believe, the most effective way of teaching the fundamentals of cookery.

The preservation of food is still a very important project with us, and during the past season reports were collected from the various counties showing that 96,847 quarts of fruits and vegetables were preserved. This, of course, is only a partial record, but it is interesting to note that where a year ago there was very little meat preserved, we have records showing that during the past season 1,662 quarts of meat products were preserved by the housewives. In addition to this there

were 10,029 quarts of pickles and brined vegetables; 20,096 quarts of jams, jellies and marmalades; 2,377 pounds of dried fruits and vegetables and 3,134 quarts of fruit juices stored for winter use. These figures are considerably lower than the previous years, but that is explained by the fact that the previous year, being a war year, people preserved all that they could, and last year they based their preservation on the amounts which their families could consume.

An account of the clothing work which is being carried on in this state is contained in the report of the clothing specialist, Mrs. Catharine H. Griebel.

The household management project has been gaining popularity during the year. The phase of this work which is most in demand is the fireless-cooker work. During the past year there have been nearly 600 cookers made in the various cooker "bees" which were conducted by the home demonstration agents. This number includes 70 cookers which have been made at meetings in Sussex and Salem counties. A survey of the farm homes which was taken last summer showed that only 2 per cent of the farm housewives in New Jersey have fireless cookers. This survey also called to our attention the fact that while 54 per cent of the farms in New Jersey have power of some kind, yet only 10 per cent have power washing machines in the homes. These figures emphasize our conviction that this is one of the most important phases of the work that we can stress in this state.

Cooperative buying of fireless-cooker utensils has been extensively carried out in Bergen, Monmouth, Morris and Passaic counties. This method of securing utensils has meant a saving of from 33 1/3 to 50 per cent to the women up to January 1, and since then a saving of 25 per cent. This spring the women united in buying jar rubbers and other canning supplies which are rather expensive in the retail stores.

The following statistics give a summary of this work:

Aluminum—	
Total amount of orders	$1,356.40
Amount saved	1,045.94
Jar Rings—	
Amount ordered	5,304 dozens
Amount saved	$371.28

The annual meeting was held in Trenton on January 15; the program was devoted to discussions of problems which come under the three major projects—food, household management and clothing. An exhibit of household conveniences was arranged in the armory which might offer suggestions to the housewives who attended the meetings. This meeting was such a success that it was voted at that time to have a 2-day program this coming year.

At the summer field meeting in New Brunswick, programs were arranged for three days. At these meetings the canning of fruits without sugar was emphasized because of the shortage and high price of sugar in the markets.

There were four conferences of home demonstration agents held during the year. Every three months the agents were called in to the central office at New Brunswick to report the progress of the work

REPORT OF THE STATE CLUB LEADER

A. M. Hulbert

A summary of the results in the various projects for the year end December 1, 1919, as gathered from the reports of the county lea at that time, is shown on the opposite page.

Policy

In our last annual report we concluded as follows:

> The real work of the state leaders, then, has become administrative supervisory in character. It is their duty (1) to know the needs of the s (2) the general program of work that has been planned for the different c ties, (3) they should get the big idea of extension across to the people in a way as to have them see the place that club work should hold in a commu program, (4) through the selection of leadership for the several counties t up an organization that shall be equal to the task that is set for it, (5) thr knowledge of conditions and experience in meeting them they should acc late a mass of subject matter dealing with the various projects, form policies and work out the best methods for putting these policies into pra and (6) finally get this knowledge of subject matter and methods to the co leaders and from them to the communities of the state through the local lea This is suggestive of the task that we have set for ourselves in club wor New Jersey for the coming year.

In order that such a task should be performed it became neces that a definite policy of procedure be adopted and that it should closely adhered to in so far as the application of fundamental p ciples is concerned. In reaching conclusions as to policy we have b guided in our thought by that which is regarded as the ultimate p pose of all agricultural extension work, viz., the improvement of a culture and home practices within the state. Viewed in this light work at once becomes an agricultural and home-economics pro and must be studied and handled as such. Every agency that can made to contribute to that end should receive our cooperation and h

The outstanding features of the policy as developed at the pres time may be stated as follows: (1) That club work with boys girls is one of the three coordinated lines of activity within the ext sion division of the State College of Agriculture, and as such sho have the same recognition as the other two lines. (2) That the operating agency which we recognize when undertaking to do w within a county is the county board of agriculture. (3) That in or to do effective club work within a county, it is just as necessary to h a trained county club leader as it is to have trained leaders for fa and home demonstration work. (4) That satisfactory results can realized only when we have a definite program of work based upon needs and natural possibilities of the county, and that the junior p ject should be a part of the general program of work for the en county. (5) That the advice and assistance of subject-matter spec

Summary of Project Results, December 1, 1919

Project or Club	Clubs Organized	Enrollment	Members Reporting	Value of Products	Cost of Production	Net Profit
Corn	11	126	10	$1,021.41	$206.26	$815.15
Potato	11	73	4	249.75	115.24	134.51
Garden	130	2,705	2,045	23,976.61	10,446.52	13,530.09
Canning	98	1,068	539	8,173.10	3,584.43	4,588.67
Poultry	60	517	163	3,994.84	2,001.71	1,993.13
Pig	32	240	75	3,396.85	2,204.76	1,192.09
Calf	7	112	89	13,960.00	4,483.84	9,476.16
Rabbit	10	81	45	613.00	254.94	358.06
Bread	10	141	64	90.12	75.10	15.02
Cooking	49	458	243	718.55	287.42	431.13
Garment making	44	531	229	1,251.34	413.25	838.09
Sweet potatoes ..	1	23	4	174.25	47.65	126.60
Dairy cow	1	7	7	2,500.00	1,275.00	1,225.00
Totals	464	6,082	3,517	$60,119.82	$25,396.12	$34,723.70

ists is just as necessary in junior project work as it is with men and women and that the same staff of specialists shall cooperate with both seniors and juniors. (6) That extension work within a county should be organized around the community as the social unit and based upon recognized needs and possibilities; and (7) that it must lead to the development of leadership that will learn how to lead and meet local needs.

Growth

It is plainly evident to one who has been in touch with the work in the field during the past 12 months that the principles which determine our policy are coming to be recognized as sound, not only by the members of the extension staff, but by the people in the counties. It is accepted that successful agriculture and efficient home making are dependent upon intelligent and approved practices and in order to secure these the whole family, father, mother and boys and girls, must form the partnership by which it is brought about. Hence, it is becoming less difficult to secure cooperation in the raising of funds and finding responsible and efficient local leadership for carrying on our work.

It will be interesting to note that one year ago we had but one county club leader permanently employed and working in cooperation with the county board of agriculture. This was Joseph B. Turpin, in Mercer County. Mr. Turpin has kept in close contact with conditions within his county and has developed an interest in projects that have been adopted by the county agent and county board of agriculture, so that today he has a definite program of work that is consistent with the needs and possibilities of his county.

At the time of the writing of this report there are 5 county club leaders permanently employed and working in cooperation with county boards of agriculture and the appointment of one leader authorized. He will begin work on July 1. The counties in which club leaders are working, with the date of appointment, are as follows:

County	*Leader*	*Date of Appointment*
Mercer	Jos. B. Turpin	January 1, 1919.
Ocean	Mrs. Lydia G. Salvador	September 1, 1919.
Morris	Harold S. Ward	January 26, 1920.
Cumberland	E. A. Howard	February 16, 1920.
Monmouth	Harold J. Krause	April 5, 1920.
Warren	Howard Mason	July 1, 1920.*

* Authorized.

In each one of these counties there either has been adopted or there is in the process of formation a definite program of work related to and a part of that which has been adopted or is to become the extension program for the improvement of agriculture and home practices for

that county. A good illustration of this is found in Ocean County. Something less than a year ago the county board of agriculture and county agent came to the conclusion that the growing of sweet potatoes should and could be made a very much better paying proposition than it was at that time. Hence, as a part of their program, the sweet-potato project was adopted. The county club leader became a factor in assisting in putting on a demonstration in the growing of sweet potatoes. There are 59 club members working under supervision and instruction on this project. They are keeping records and at the end of the season they will be able to make definite reports which, with their exhibits of products, should give some indication of the possibilities in the raising of sweet potatoes in Ocean County. Another striking example of this kind of organization and program making is found in Mercer County. Here dairy and swine work became a part of the county program. The county club leader was recognized as having his part in the plans and at once began the organization of dairy and swine clubs. In the dairy clubs emphasis was placed upon the importance of better bred stock, with the result that a real interest in pure-bred dairy stock is developing in several of the communities. The swine clubs emphasized both the fattening and the breeding projects. The greater interest seems to have been developed through the pure-bred swine clubs, and it is a satisfaction to note how interest in better stock is growing. Data are accumulating by which progress may be shown.

Cooperation Within Unorganized Counties

Our work is not wholly confined within counties that are organized under permanent leaders. We have carried through the year just closing part-time paid leaders in Cape May, Camden, Hunterdon and Salem counties. In Atlantic County the work is done in cooperation with the director of the vocational schools and his assistants. This form of organization and cooperation has resulted in the creation of a great deal of interest and the accomplishment of much that will be of enduring good, still it is obviously impossible to secure the same satisfactory results as where there are full-time permanent leaders. It shall be our policy in the future to discontinue part-time leadership and appoint full-time leaders just as fast as the counties are ready for cooperation.

In the hot school-lunch, further mention of which will be made later, the assistant state leaders have cooperated with the county superintendents of schools helping teachers, principals and teachers in the accomplishment of some very real and interesting results.

Relations With Extension Specialists

As noted above the extension specialists in subject-matter are part of the machinery by which the program is formed and carried out. During the year A. Freeman Mason has given valuable assistance in developing a junior fruit project, and three clubs, the first to be formed in the state, have been organized in Warren County. Reports indicate that these clubs are doing good work. J. W. Bartlett, extension specialist in dairying, with a committee of county club leaders, has worked out a dairy project as a part of the dairy program for the state. This project with such modifications as are necessary to meet local county conditions, is now working in 9 counties. In a similar way I. L. Owen, extension specialist in poultry husbandry, has assisted in working out a poultry project. This project has been adopted and will be put into operation in the fall, beginning about October 1. Chas. H. Nissley, extension specialist in market gardening, is now working with a committee on market garden and can-house tomato projects. These projects will be ready for use another year. From time to time the specialists visit the demonstrations of club members, meet club groups and prepare follow-up material for use by leaders and the boys and girls.

Local Volunteer Leadership

Eighteen months ago there was much skepticism among our workers as to soundness of the theory of securing and training local leaders. Traces of this skepticism may still linger in the minds of some, but the process has been going on so long, and the effects are becoming so apparent, that there is no longer any doubt in the minds of most of our people as to the soundness of the principles. It can be done, for it is being done. Some very interesting group meetings for the purpose of giving training in local leadership have been held in several counties with satisfactory results, notably in Mercer, Ocean, Morris and Middlesex counties.

One source from which we are able to draw some of our best local leaders is from among the club members themselves. One of the ideals of club work should be the training for leadership. Mercer County, Cumberland County and Hunterdon County are furnishing such leadership.

Hot School-Lunch

The work with this project has been somewhat unique and seems to call for special mention in this annual report. As stated above, it was organized by the assistant state leader, Miss M. Ethel Jones, in cooperation with county superintendents of schools and teachers. Hot school-lunch clubs were started in 36 schools in 10 counties. Of this

number 21 made a detailed report in response to a questionnaire that was sent out from the state club office. Nineteen of the schools reporting state that club groups have been organized within the schools for the purpose of carrying on the work and that these groups have held regular meetings for the purpose of studying and planning menus, keeping records, etc.

Of all the schools in which hot-lunch clubs were organized only two reported in any way unfavorably, and these reports were as follows: (1) Too much responsibility falls upon one teacher; the responsibility should be divided, (2) it requires, at least, ½ hour of play or work time, (3) a need for better quarters in which to keep the equipment and do the work. Twenty-one reported favorably with such comments as, (1) children eat more slowly and enjoy lunch much better, (2) socializes the noon hour, (3) more healthy children, (4) children can study better in afternoon, (5) teaches table manners, (6) teaches cooking of simple dishes, also serving, (7) teaches economy of food, also proper food combinations, (8) teaches cooperation by learning to work with others, (9) a gain in the knowledge of bookkeeping, (10) it is valuable to poor children who are unable to bring sufficient food.

Conferences of State and County Leaders

Since our last annual report there have been held a number of committee meetings of county leaders, state leaders and subject-matter specialists and one state conference of all state and county leaders. The committee meetings have been for the purpose of studying and planning projects in various lines of work. The results of these conferences are plainly evident in the greatly improved type of work that we are finding in dairying, poultry management, swine husbandry, market gardening, fruit work, etc. It is clear to the state leaders that a definite goal is being set and that the county and local leaders are conscious of the fact that our boys aud girls are headed somewhere.

The conference of state and county leaders was held at the college on March 4, 5 and 6, 1920. Each county leader made valuable contributions to the constructive thinking and planning for the work of the whole state. Perhaps some of the most helpful suggestions should be mentioned. Mrs. Salvador, county leader in Ocean County, gave a constructive talk on the subject of office organization and the development of local community organization and leadership. Mr. Turpin, of Mercer County, spoke of the organization of projects of the all-year round plan which aims at permanency and definiteness of program. Mr. Howard, of Cumberland County, told of how he had the work for the year planned so as to make it possible to follow-up his clubs and see that they finish their projects. Each specialist whose name appears on the program came with a real message and with a definite suggestion for the improvement of our work.

Visits into the various counties by the state leaders since have revealed the fact that the suggestions are being put into operation.

Miss Nancy McNeal, home economics specialist and assistant state club leader from Cornell University, gave most interesting and helpful suggestions for our home economics clubs. The exhibits which she showed presented many ideas of a practical nature which have been adopted by our leaders. George E. Farrell and Milton Danziger, from the Washington office, added greatly to the value of the conference by their talks and suggestions. One definite result which followed was the starting of a demonstration in Mercer County in which we propose to show how the three lines of work, farm demonstration, home demonstration and club work, should all form contributing factors in developing and carrying out a county program of work.

Annual State Club Meeting and Conference

The annual state achievement club meeting and conference was held at the college on June 22 and 23. It was attended by members from 18 counties and the total attendance was somewhat in excess of three hundred; the largest that we have ever had. The program, as planned, was carried on in all of its details. The largest attendance from any one county was 86. These were from Middlesex County.

There were two outstanding features of this meeting which shonld be noted. The first was the assistance which was rendered by the extension specialists on the second day. After assembly on the Rutgers Campus the entire delegation marched in a body to the College Farm, a mile and a quarter distant, where they divided themselves into five groups, viz., dairy group, garden group, poultry group, home economics group and animal husbandry group, each group going to its respective station.

A question that has troubled us for some time, and for which no answer seemed to be forthcoming, was how to keep in touch with club boys and girls after they pass the club age and how shall we use the leadership which should have been developed in them through their club experiences and activities. The second outstanding feature of the annual meeting contains at least a suggestion of an answer to our question. By special arrangement 18 achievement club members representing that many counties were brought to the College with the thought of holding a special conference for the purpose of possibly starting a state-wide organization of boys and girls and young men and women who have been recognized as achievement club members for two or more years, and also for the purpose of spreading the gospel of club work and of keeping contact with the young people who are reached through our club organization. The plan was laid before a group of some 25 or 30 of such young people, including the 18 that had been brought in, and it was interesting to get the reaction that

followed the presentation of the scheme. The plan was unanimously adopted and a committee consisting of four achievement club members, one county leader and one state leader was formed forthwith for the purpose of drawing up plans and presenting to a future conference some form of organization. The committee appointed consists of Joseph B. Turpin, county leader of Mercer County; Clarence Alles, achievement club member of Hunterdon County, who is now representing club work on part time and being paid for his services; Mary Leaming, who is now engaged in her sixth year of club work; Mary Bohn, of Mercer County, who is engaged in her fourth year of club work, and Helen Morton, of Bergen County, who is engaged in her fifth year of club work. This committee will be heard from some time in the near future.

Enrollment by Projects

A summary of enrollment by projects for the state is as follows:

CLUB	Number of Clubs	Total County Enrollment
Corn	20	135
Potato	34	159
Garden	74	1591
Pig	34	266
Dairy calf	12	97
Poultry	56	637
Canning	58	876
Bread	5	153
Sewing	53	585
Cooking	64	771
Orchard	3	17
Rabbit	3	59
Agricultural clubs	24	314
Totals	440	5660

This number is somewhat less than the number reported a year ago. It is our judgment, however, that it is an indication of a better condition in the counties and it will no doubt result in a very much larger percentage of our members finishing creditably.

The number of local leaders reported by county leaders to date is 185.

Cooperation and Relationships

This annual report should not be concluded without a word of appreciation given for the cordial cooperation that we have enjoyed with institutions and organizations with which we are associated more or less closely but between which and ourselves there are no official relations.

The public schools, without exception, through the state commissioner of education's office, the county superintendents of schools, helping teachers, principals and teachers, have manifested a most cordial attitude, and it is largely through their cooperation that we have been able to carry our work forward.

The Smith-Hughes schools, through the cordial relations which we have enjoyed with Prof. H. O. Sampson, supervisor of agricultural education, have assisted in our work, and the teachers in these schools are acting as local leaders of clubs. Agreement with these schools through Professor Sampson has been reached whereby duplication of enrollment and work is entirely avoided. This understanding is as follows:

Pupils enrolled in vocational classes are not to be enrolled as club members, except that any club member who enters a vocational class in agriculture is to be allowed to finish any club project that he has started, this work to be done according to the "program of work" for that particular project as outlined by the extension division for that county.

The chief reasons for not enrolling vocational pupils as club members are:

(1) Vocational pupils receive the benefits of organized school instruction and supervised home practice in agriculture for an extended period each year, and it is unfair for them to compete in project work with club members who do not receive such instruction.

(2) Vocational pupils, if they devote the necessary time and energy to their vocational projects to make the work truly vocational, have their needs met and do not have time to carry on club projects in addition.

Approved: (Signed) L. A. CLINTON,
Director of Extension.
(Signed) WESLEY A. O'LEARY,
Ass't Commissioner of Education in Charge of Vocational Education.

The Inter-State Fair Association has been most liberal in the support which they are ready to give in making money and space available for exhibition and demonstration purposes. They are turning over for the exclusive use of the club section next fall the whole of a building 30 by 200 feet. This space will be entirely filled with cluh exhibits and demonstrations.

Last year the agricultural committee of the State Bankers' Association made available funds in sufficient amount to offer a pure-hred sow pig as a prize in every county in the state in which organized pig club work was carried on. Eight counties entered the contest, viz., Mercer, Cumberland, Hunterdon, Morris, Essex, Ocean, Monmouth and Atlantic. Eight pure-bred registered sows have been placed in these counties. In two of the counties girls were the winners. Each boy and girl receiving a pig signed a contract to keep it at least 2 years and breed from registered stock of the same breed. This work has

REPORT OF THE EXTENSION SPECIALIST IN CLOTHING

MRS. CATHARINE H. GRIEBEL

Since December, 1919, clothing work in New Jersey has become much more definite and satisfactory. It was only natural that the first months, May to December, 1919, should be a period of getting acquainted with the women of the state in order to know their needs. At first we undertook whatever interested the community, be it made-overs, millinery or what-not. Gradually, however, came a demand for basic principles in cutting and fitting and, at the present time, we are working almost entirely along that line.

Alteration of commercial patterns to suit individual needs is a state-wide project and women of all classes are interested. One day, 9:30 a. m. to 5:00 p. m., completes the permanent pattern, and the house dress, which is used to test the pattern, is basted and ready to finish. It is a saving of money without doubt, but far more important is the saving of time and nervous energy when our women are able to make their simple dresses without try-ons. Not only are they using their altered patterns for their own clothes, but they are helping others in their communities to make permanent patterns. From January 1 to July 1 the making of a permanent pattern from an altered commercial pattern and the cutting and basting of a dress from this pattern has been given to 180 women. The following survey, taken June 30, 1920, of 8 group meetings conducted by the specialist during April, May and June, in counties where there is no home demonstration agent, shows that the work is going forward:

Total number in groups	46
Total number reporting	32
Dresses made from altered pattern	48
Waists made from altered pattern	5
Skirts made from altered pattern	4
Number helped by 32 reporting	26

A meeting was held in Bergen County recently with leaders from 9 communities. These leader groups will be conducted by the specialist during July, and the leaders will then assist the home demonstration agent in carrying this project throughout the county.

Dress forms, made like those used in the best schools of dressmaking, is another project which many counties have taken up and we are depending on local leaders to assist in the work. One group of 9 women was held by a member of the original group conducted by the specialist. Since January 1, 1920, in Monmouth, Mercer, Passaic and Bergen counties, 143 women have made forms at a saving of $1,824.39. This saving is estimated on the difference in cost of the cheapest adjust-

able form, $17.00, and the cost of the material used by each woman, about $4.50, although some utilized old forms and the saving was greater.

Millinery is to be made a definite project in some parts of the state and plans are under way to train leaders to help with this work. During the spring months in Bergen and Passaic counties, 177 hats were made at a saving of $1,000.61.

Summary

Lectures	38
All-day group meetings	31
Attendance	1,786
Training groups	4
Leaders trained	17
Letters written	100

REPORT OF THE SPECIALIST IN VEGETABLE GARDENING

C. H. NISSLEY

The vegetable industry in New Jersey ranks very high in the agricultural interests of the state, mainly because of two factors—first, its location near the largest and best markets of the East, and second, the adaptability of the soil under good management to produce early and heavy-yielding crops. The increased population during the summer along the shore resorts, produces a demand for fresh vegetables at a good price, and forms an outlet for the supply of those gardeners more remote from the larger cities. The type of gardening varies greatly and reaches the two extremes; the very intensive gardeners located near the larger cities and operating only a few acres, and those more remote from the cities and operating hundreds of acres. Every named variety of vegetable is grown in the state, together with the potherbs, therefore making extension work more or less difficult except with the important crops as tomatoes, sweet potatoes, peppers, celery, onions and sweet corn.

The results for the year 1919-20 are included in the detailed discussion under the various projects.

Project 1, Can-House Tomatoes

This work is carried on as a county program, there being but one demonstration plot in each county where can-house tomatoes are raised extensively, including Cape May, Cumberland, Salem, Gloucester, Camden, Burlington and Mercer. Each demonstration plot is one acre in size and includes practically all of the sub-projects listed under the *main project.*

Varieties

The seed used was of the Bonny Best variety for the second early, and in the southern counties the Greater Baltimore was used for the late crop. In past demonstrations these varieties proved to be better than any of the other varieties grown, are particularly adapted for shipping, and are considered good can-house tomatoes. These varieties on the demonstration plots will be compared with those grown by the demonstrator, accurate records being kept.

Many varieties are grown for the can-house. The general practice was to grow one variety, planting the seed at one sowing, and setting the plants in the field at one planting. The result was that the bulk

of the picking season came on at one time, and it was almost impossible to handle the crop with the ordinary amount of farm help. The canning houses at this time also were unable to handle the tomatoes properly, on account of the large quantities coming in at one time. The main purpose of this demonstration is to secure varieties which ripen the greater part of their fruit at different times.

In Cumberland County a can-house tomato variety test was conducted by County Agent W. W. Oley in 1918. to ascertain the best varieties and the approximate time of ripening their crop. A summary of the demonstration shows that the Greater Baltimore variety leads as the heaviest yielder of the varieties grown, with Bonny Best and Matchless following in order. Bonny Best ripened 45 per cent, Greater Baltimore 34 per cent, and Matchless 26 per cent of their crop before September 7, all varieties being planted on the same day. By planting Bonny Best three weeks earlier, the heaviest pickings of that variety would be made before the bulk of the later crops come on. From September 1 to the 20, 60 per cent of the Bonny Best, 64 per cent of the Greater Baltimore, and 57 per cent of the Matchless ripened, and the later period from September 15 to the end of the season, Bouny Best ripened 39 per cent, Greater Baltimore 33 per cent, and Matchless 61 per cent of their crops. By careful planning and selection of varieties, the picking season can be distributed from August 1 until frost, instead of having the bulk of the crop come on in a period of three to four weeks. The type of soil must be considered when selecting the varieties to grow, as varieties differ considerably on different soils. These three varieties are grown more than any others, and are preferred by the canners.

Variety demonstrations in North Jersey on market tomatoes were conducted this year in Bergen and Passaic counties, but because of the weather conditions the results were not as marked as in ordinary years. Because of the dry weather in the early spring followed by the extremely wet weather during the summer, the growth and set of fruit was greatly reduced. Samples of stock seed of Gloria, Bonny Best, Chalk's Early Jewel, John Baer, Greater Baltimore and I. X. L., were obtained from the originators of the various varieties when possible. Although all of these varieties were being grown in the county, the growers wanted new stock from which to save seed.

Only one man kept a detailed record of the pickings made from 25 plants, the results being as follows:

	Yield Per Plot	*Yield Per Acre*
	lbs.	*lbs.*
Home-Grown	105	11550
Gloria	75½	8305
Bonny Best	94	10340
Chalk's Jewel	83	9130
John Baer	91½	10065
Greater Baltimore	70½	7755
I. X. L.	52½	5775

The Bonny Best variety gave a very good yield; however, the fruit was small, and the majority went on the market as seconds, or culls, while the Chalk's Jewel gave the largest yield of large-grade fruit, even surpassing the cooperator's own strain. Although no records were kept in Passaic County, the cooperators agree that the Chalk's Jewel variety gave an increased yield, together with a large proportion of large fruits.

Better Plants

The common practice in South Jersey is to plant the seed of the late tomatoes out-of-doors, and to plant them directly into the field from the seed-bed. It has been demonstrated by the best growers that starting the plants early under glass, transplanting them once into a cold frame and setting into the field not later than May 20, not only increased their yield from 50 to 75 per cent, but increased their gross income as well. The late blight does not have as much chance on the earlier, healthy plants, as it does on the later ones, or the more or less weak seedling plants. Therefore, the use of strong, vigorous, transplanted plants is demonstrated.

The following is the result of a demonstration in Camden County in the year 1919-1920: The growers of can-house tomatoes rarely transplant the young plants before setting into the field. The plants are taken directly from the seed or plant-bed, and set directly into the field. In many cases the grower will not have enough frame space to transplant. For early market tomatoes, two and three transplantings are made, since this operation tends to hasten maturity and set more early fruit.

This demonstration was conducted in Camden County by Wm. H. Garwood, Merchantville, who usually plants many acres to can-house tomatoes. The cooperator was much interested and kept accurate record of all pickings and results. The project will be given more attention next year when cooperators in other counties will be secured, to increase the yield per acre of the can-house tomato crop. The following is a report from County Agent H. R. Cox:

In order to show the supposed superiority of tomato plants spotted or transplanted in the hot-bed as compared with so-called seedling plants, that is, those which have not been transplanted but planted directly from the place, the seed was originally sown to the field, a demonstration was made on the farm of *Wm. H. Garwood, Merchantville.*

Seed of the variety Paragon was sown in the hot-bed on February 24. On March 30, part of the lot of young seedlings were spotted. On May 14, both lots were set in the field. The area selected for the demonstration was a piece of uniform, rather heavy soil. There were enough spotted plants for 10 rows and seedling plants for 20 rows. The distance of planting was 5 by 3½ feet and the rows contained 208 plants each.

On May 22, the spotted plants appeared to be much larger and more thrifty. Apparently they stood the attack of the adult potato bugs better than the seed-

lings. On July 10, there appeared to be more early blight on the spotted tha: in the seedling plants, although the disease was not bad on either plant.

In the following table the actual yields of the spotted plants are given, bu the yields of the seedling plants are divided by 2 in order to make the result from the two plants comparable:

DATES OF PICKING	Yield	
	Spotted	Seedling
	baskets	baskets
Before contract started	10	..
Aug. 6	25	7.5
Aug. 14	35	20
Aug. 20	80	55
Aug. 26	55	55
Sept. 2	15	15
Sept. 9	10	10
Sept. 16	7	5
Totals	237	167.5

The 10-row plot of each kind of plant occupied 0.83 acre. The total yield o! the spotted plants, therefore, was at the rate of 5.28 tons per acre and of th seedling plants 3.73 tons, an increase of 1.55 tons per acre.

Fully as important as the total yields is the relative dates of maximum pro duction of the two kinds. It will be noticed that the spotted plants produce a much larger proportion of its crop early, than the seedling plants did. Thi means a larger difference in money returns on market tomatoes. Mr. Gar wood's crop was contracted, and although the earliness of production of th spotted plants was not so great an advantage in contract tomatoes as in marke tomatoes, it is of some value. There is a premium of $2.00 per ton offered b the Campbell Company for the early fruit. Furthermore, it will be notice that 10 baskets were sold in the market before the contract season opened These brought a high price. In 1918 Mr. Garwood had 20 acres in contrac tomatoes largely spotted. He had sold $600.00 worth of early tomatoes befor the beginning of the contract season. Mr. Garwood believes that even in th case of contract tomatoes it pays to spot the plants. This year with 15 acre in tomatoes he had 10 acres spotted. He would have spotted all his plants i he had had sufficient hot-bed facilities.

Fertilizers

The use of proper fertilizers on can-house tomatoes is being demonstrated in comparison with the demonstrator's own mixture. On the "second earlies" where a cover crop is plowed under, 1,000 pounds of a 4-8-4 fertilizer will be used; 400 pounds of which will be applied in the row at least 8 to 10 days before planting and the remaining 600

pounds side-dressed within 6 to 8 days after planting. For the late varieties only 800 pounds of a 4-8-4 will be used, 400 pounds in the hill 8 to 10 days before planting, and 400 pounds as a side-dressing. Where manure is available and applied in quantities of 15 to 20 pounds to the acre, from 400 to 600 pounds of a 4-8-4 will be used in the row. Acid phosphate alone also will be used on part of the demonstration plot to show its value where manure is applied in such quantities. Additional applications in the form of nitrate of soda and sulfate of ammonia will be demonstrated by the vegetable specialist.

Spraying

One-quarter of each demonstration acre plot will be sprayed with the standard 4-4-50 Bordeaux mixture for the control of leaf spot and late blight. These sprayings will begin at least 10 days before the first appearance of the disease in that locality, and will continue for 10 weeks, at intervals of every two weeks. The picking records from this sprayed plots will be kept separate to demonstrate the increased yields, especially on the "second earlies," to be derived through spraying. Very few men in New Jersey spray for the late blight; however, those men who do spray find it to be worth while. Where insects are at all prevalent on the demonstration acre, either spraying or dusting will be done with the proper material for their control.

Seed Saving

On each demonstration acre, tbe vegetable specialist will stake as many plants as possible which have the desired characteristics from which seed should be saved. At the summer meeting of the tomato growers on the demonstration, these points will be emphasized and the men will have a chance to see just how the plants were selected. The home-selection and saving of tomato seed is of great importance, because much of the seed is secured from can-houses, and is nothing more than cannery-run seed which is purchased for $1.50 a pound, while good seed is worth from $18 to $20.

A state-wide campaign is being run through the various county tomato growers' organizations for the home selection and saving of tomato seed. The detailed outline contained in Extension Circular 13 gives full information, and will be placed in the hands of every tomato grower possible.

Cover Crops

All can-house tomato growers were strongly urged to supply more organic matter to their soils, and this in the form of cover crops plowed under before the planting of the crop. The scarcity and high price of

manure compels these men to adopt some such scheme in supplying th organic matter. On each demonstration plot, a cover crop will b planted, broadcasted either at the last cultivation or after the crop ha been harvested. This will be especially true for fields intended for can house tomatoes the following year where a rotation will be such that cover crop can be planted.

Cost Accounts

Accurate records will be kept of everything purchased, labor re quired, and tomatoes sold off the demonstration acre, and of the farm er's acreage, so that accurate records may be secured as to the cost c growing can-house tomatoes.

Project 2, Market Tomatoes

The work done on market tomatoes is in the northern part of th state and as far south as Monmouth County. Most of these tomato are placed directly on either the Philadelphia or New York market.

Varieties

In certain outlying sections of North Jersey, especially in the v cinity of Dover and in parts of Bergen County, tomatoes of po quality are being grown. Varieties such as the Earliana, and po strains of other commercial varieties, have been grown and have give very unsatisfactory results. Therefore, variety demonstrations a now in progress in both Morris and Bergen counties, which inclu stock seed of the Bonny Best, Greater Baltimore, John Baer, Chalk Early Jewel and Matchless. These varieties are being grown alongsi of the growers' own varieties. The best plants will be staked, and se saved from the various varieties, and especially those producing th highest yields of most desirable fruit. This seed will be distribut throughout the community for use the next year, when every grow will be expected to save his own seed.

Fertilizer

Few tomato growers in North Jersey fertilize with the same m terials. On the majority of the farms large quantities of manure a applied each year, which would tend to reduce the amount of a hig grade fertilizer which these men are using. The demonstration i cludes fertilizer formulas used in the county ranging from a high r

trogen content and a high and a low potash content, and also a straight 16 per cent acid phosphate plot. Acid phosphate alone on the tomato experiments conducted by the Experiment Station, both at New Brunswick and at Masonville, produced the highest yields, and, therefore, a cash saving to the growers.

Control of Late Blight

Few tomato growers in North Jersey spray their crop for the control of the late blight. The few, however, that do spray are very well satisfied with the results, obtaining a greater yield, due, of course, to the fact that they forestall the attacks of the late blight. On the market tomatoes in Bergen County, two spraying demonstrations are being conducted. The sprays are to begin at least two weeks before the first appearance of the blight and to continue at intervals of two weeks until the first of September. Accurate records will be kept on the sprayed and unsprayed blocks.

Acid Phosphate

Where manure is easily obtained, especially in the vicinity of the larger cities, the heavy application of manure, together with large quantities of a complete fertilizer, is wasteful, and produces too large a vine at the expense of the fruit. Smaller applications of manure we recommended, plus the use of acid phosphate, applied at the rate of 500 to 700 pounds of acid phosphate per acre. Where no fertilizer has been applied in connection with the manure, 500 to 700 pounds of acid phosphate is recommended to make up for the deficiency in phosphoric acid in the manure. Four demonstrations have been scheduled in Essex County, and will mean both an increase in the crop and a saving to the user of a high-grade fertilizer.

Blocking

The blocking of early plants in the cold-frame continues to be an important and interesting demonstration in new sections. In every case the tomatoes were brought ou at least two to three weeks earlier than the unblocked plants, and this year the difference is even greater. In tbe Montague section of Sussex County and in the Dover community, as well as in parts of Bergen and Essex counties, the results are showing up very well so far this season.

Home Seed-Saving

The home selection and saving of tomato seed on the market tomat is being carried on the same as the can-house campaign. Extensioı Circular 13 has been sent to the county agents, and meetings will b staged throughout North Jersey similar to those in South Jersey oı the selection of tomato plants and the proper way of saving seed Those men who have been saving their seed for years, are not only sat isfied themselves but are making their practices felt among their neigh bors who do not follow this method.

Project 3, Sweet-Potato Demonstration

The Jersey sweet potato has a wide reputation over the Unitec States, and in order to maintain the reputation it is necessary that up to-date methods be practiced by the grower, which not only include the growing or culture of the crop, but the disease-control work, a well as the proper storage conditions. It is estimated that of the 3,000,000 bushels raised in this state, 1,000,000 bushels are lost through disease in the field, 1,000,000 bushels rot in storage, and the remaining 1,000,000 bushels finally find their way to the market Plans have been drawn for a flue-heated hot-bed supposed to be the carrying agent for disease organisms. These plans will be distributed for the use of the growers wishing to build them. Information has been given also in reference to the proper storage of sweet potatoes, a well as the remodeling of old and inefficient storage houses, and putting them into modern shape.

Variety

In Ocean County, especially, the growing of this crop has never been a large industry, the largest area on any one farm being not over three acres, although almost every home garden contains a couple hundred hills to supply the demands of the family. The soils in this county are particularly adapted to the growing of the crop; therefore, in order to start right, a variety demonstration was scheduled. The county agent secured all the different varieties grown in the county, and the specialist secured from the United States Bureau of Plant Industry the following varieties: Nancy Hall, Porto Rican, Triumph, Pumpkin and Southern Queen. After the potatoes are dug in the fall, a quantity will be stored so as to determine the storing quality of the various varieties, also the yield and quality.

Fertilizer

The majority of sweet-potato growers in South Jersey have always used manure in the row to grow their crop. Many of these men are of the impression that sweet potatoes cannot be grown without manure, and at the present time this commodity is very hard to obtain. With this demonstration it will be shown that sweet potatoes can be grown without manure by the judicious use of a proper commercial fertilizer, coming in a rotation where a cover crop can be turned under to supply organic matter to the soil. The fertilizers used in these demonstrations include the following mixtures: 2-8-4, 4-8-4, 6-8-4, 4-8-0 and 4-8-6.

Project 4, Pepper Demonstration

New Jersey grows 53 per cent of the peppers grown in the United States. The soils, especially in the southern and central parts of the state, are particularly adapted to the growing of this crop successfully. On the majority of the soils which require more or less plant-food, growing peppers would not be a paying proposition. For the first time work was started this year with this crop for increased production.

Fertilizer

Much manure and very little fertilizer was used, especially on the light, sandy soils. However, because of the scarcity of manure, a good cover crop to be plowed under, occurring in a definite rotation, and supplemented by a commercial fertilizer, is being worked out. A combination of many fertilizers already used in the pepper section is being demonstrated on the various plots in the counties. The nitrogen supply varies from 2 and 4 to 6 per cent, phosphoric acid from 8 to 12 per cent, and potash from 0, 3, 5 and 7 to 9 per cent. In Cape May and Cumberland counties nitrogen in the form of king crab also is being demonstrated in comparison with a commercial fertilizer.

Seed Selection

In the last few years the pepper seed obtained from the various seedsmen has been of very poor germinating qualities; in some cases none of the seed germinating. The pepper grower is urged to save some of his own seed, especially for his own use, and demonstrations are being started in comparison of commercial with home-grown seed.

Project 5, Sweet-Corn Demonstration

The growing of sweet corn in North Jersey, especially near the larger markets, is an extensive industry. Many new sections, notably in Morris County, are going into the production of this crop, and it is estimated that in Bergen County alone over 1,800 acres of sweet corn is grown. This industry is important to a certain extent in the central part of the state, especially along the Delaware River in Mercer, Burlington and Camden counties.

Variety Demonstration

In Morris County the growing of sweet corn is becoming of greater importance because of the large demand from the Newark, Jersey City and New York markets. The variety of corn grown in certain sections was of poor quality and low yielding. The sweet-corn-variety demonstration has been planned and is developing well in the Hanover Neck community. Important strains of the leading varieties, such as the Howling Mob, Evergreen, Golden Evergreen, Early Mammoth, Golden Giant and White Evergreen, together with other varieties grown in the county, are being used. Accurate records will be kept at the time of picking, and seed will be saved from the various plots. A quantity of seed of each variety has been kept in the office of the vegetable specialist, so the stock seed may be obtained for the production of varieties showing the different characteristics.

The Improvement of Sweet Corn by the Ear-and-Row Method

Practically every sweet-corn grower in the state saves his own seed; however, no effort is made in the careful selection of seed. As a general rule two or three rows along the side of the field are allowed to stand, and the next year's seed is selected from these rows, practically everything being taken. The ear-and-row method will be carried out as a county project in Bergen and Morris counties. This project is of 3 years' duration, and provides for a breeding plot the second and third years. Pictures of the ears selected this year have been taken, and will be compared with those at the end of the demonstration.

Corn Ear-Worm

This insect causes much trouble and damage to the midseason and late corn in central and southern New Jersey. Experimental work carried on by Dr. T. J. Headlee, entomologist, in Camden County,

showed that the injury could be greatly decreased by the use of a dust composed of arsenate of lead and either lime or sulfur and applied at the proper time. A demonstration to show that the insect can be controlled is being conducted in Bergen County this year.

Project 6, Cabbage Demonstration

Both early and late cabbage hold important places in vegetable production in this state. In the last few years much trouble has been experienced by the growers in both insect and disease work and in the proper growing of the plants.

Variety Demonstration

In the vicinity of Philadelphia, on the Jersey side, the cabbage industry years ago was very extensive, thonsands of acres being grown for the Philadelphia and New York markets. However, this crop has become practically extinct as a result of the ravages of black leg and yellows. At the present time we have 20 varieties and strains to be grown in Camden County, including two of the yellows-resistant varieties from Wisconsin, and seven or eight varieties locally grown, the seed being produced on the same farm. Other varieties have been secured from Long Island and New York State, for the improvement of the varieties in that section. The results of this demonstration will benefit not only Camden County, but Burlington, Gloucester and parts of Salem County.

Fertilizer Demonstration

Fertilizer demonstrations in North Jersey are under way to show the importance of acid phosphate on heavily manured soils. This fact has already been demonstrated in Bergen County, where an increase in both the yield and the size of the head has resulted. As a result this demonstration is being put on in other counties in North Jersey.

Cabbage-Maggot Control

The early cabbage in certain sections of New Jersey suffered very greatly from the cabbage maggot, in some cases reducing the yield from 50 to 70 per cent. Demonstrations are being conducted on the use of water-gas tar and sand. One pint of water-gas tar is added to 1 bushel of sand, and about one teaspoonful of this is placed around each plant immediately after being set in the field. This treatment will not kill the fly nor the egg, but acts as a repellant, and will keep the fly away from the plant and from laying its egg near the plant. This is a

common practice with the early cabbage and cauliflower growers in Bergen and Passaic counties, but has never been used in other parts of the state.

Project 7, Celery Demonstration

The celery acreage in New Jersey is restricted to a certain extent to the central and northern part of the state. This work was carried on mostly in the market-garden sections where much manure is available. Demonstration work in celery is on practically one subject.

Controlling Late Blight

In certain sections of North Jersey the late blight does much damage to the crop. Demonstrations have already been scheduled for the celery-growing sections in Bergen and Passaic counties, for the control of this disease. This demonstration will continue throughout the season, the celery being sprayed a day or two before it is trenched. Unsprayed celery to be trenched at the same time will form a check.

Project 8, Horse-Radish Demonstration

This crop is not included in the crops of great value; but in the Brookdale community of Passaic County much horse-radish is grown. Growers in this district, although having small acreages, have requested the help of the specialist with their manure and fertilizer problems.

Fertilizer

The scarcity of manure has compelled the horse-radish growers to reduce the amount applied and resort to commercial fertilizers. Last year fertilizer treatments alone in a demonstration plot gave very good results in reference to lighter applications of fertilizer. The same demonstration is being duplicated this year on another farm to check up the results of last year, and also an additional plot was taken on to show the effects on the root where the fertilizer is plowed under instead of being applied on the surface.

Project 9, Seed-Bed Sterilization

The results of this work have spread very rapidly, and many requests are coming in for help on this project. Even the pepper grow-

ers in South Jersey are finding that it is hard to grow their peppers and eggplants on account of diseases in the seed-bed. Unless the price of formaldehyde takes a sudden change, very little work on the use of formaldehyde will be outlined. If the growers will organize and purchase a steam boiler cooperatively steam sterilization will be used. Last year's results have proven to the growers the advisability of sterilization. Where the seed-bed has been sterilized, a few lettuce plants have gone down with the lettuce drop, while plants from an unsterilized bed averaged as high as 100 to 125 plants per frame of 25 sash, making a total loss of between $25 and $40 for one frame of 25 sash.

This demonstration proves to be one of the most important for market gardeners in North Jersey, especially for the men who grow lettuce under glass. Two years ago, 40 pounds of formaldehyde was used in sterilizing one seed-bed. Last year over 900 pounds of formaldehyde was applied to control the disease, and the results are very encouraging. The plans for this year have not been made, since formaldehyde has gone up in price over 100 per cent, making sterilization with formaldehyde expensive. A committee has been appointed in the Richfield Community to look into the purchase of a steam boiler so that steam sterilization methods may be taken on.

Miscellaneous Work

Cover Crops

Time was spent with the various county agents to induce men in certain communities to plant cover crops after the vegetable crops have been removed. With the scarcity and high price of manure cover crops seem to be the cheapest and best solution of the plant-food problem at this time.

Asparagus

Although New Jersey produces much asparagus, and is second to California in total production, very little work has been done with this crop. This spring 4 pounds of the Martha Washington asparagus seed secured from the United States Bureau of Plant Industry was distributed throughout the state. John Middleton, of Port Jervis, Sussex County, received 1 pound, and Arthnr Randolph, of Bound Brook, a large asparagus grower, received 2 pounds, from which to grow plants to be distributed throughout the state. The other pound was distributed to individual growers.

Seed Saving

The home-growing and saving of vegetable seed throughout the state has been strongly urged by the specialist. The growers are beginning to realize the importance of this practice and are requesting information in reference to the production and saving of practically every vegetable seed with the exception of cauliflower and a few other more or less important seeds.

Home Gardens

The call for information on the home gardens throughout the state has increased in the last year; however, many of these requests were referred directly to the county agents in the various counties. In Bergen County the home gardeners are organized by the county agent into clubs, and any request or call from any member of the club is submitted to the chairman of the clubs and brought out at the meeting where all members receive the benefit of the organization. A set of lantern slides was made up by the extension division for this work. The boys' and girls' club leaders also have used these slides for lecture work to the clubs.

Activities

The use of a personally owned automobile has greatly aided the specialist in carrying on the work under way, making it possible for him to carry materials and equipment, and also saving time in going from one county to another where train service is poor.

During the winter the specialist's time was taken up by institute lecture work, community meetings and home-garden talks, many of which are illustrated. Also the projects are written in the early fall and winter, and plans in general made for summer project work.

"Timely Tips to Gardeners" were written and sent out each week during the growing season to the newspapers of the state for the benefit of home gardeners. Two circulars were written, one on the culture of horse-radish and the other on the home selection and saving of tomato seed.

REPORT OF THE SPECIALIST IN SOIL FERTILITY AND FARM CROPS

HERBERT R. COX

J. B. R. Dickey, who had been extension specialist in soil fertility and farm crops since March 15, 1916, resigned on January 31, 1920, and the present incumbent, who had served as county agricultural agent of Camden County since 1917, was appointed on April 1, 1920, to the position vacated by Mr. Dickey.

Corn

Corn variety demonstrations were carried on during the season of 1919 along nearly the same lines as in the years past. There was a total of 64 of these demonstrations in the 14 counties which conducted this work; the number of demonstrations to the county varied from 2 to 18. In 7 of the counties meetings were held at one or more of the demonstrations, with a total attendance of 515 persons.

The plan of this demonstration is to assemble a number of strains of corn which seem to be well adapted to the region and grow them side by side under identical conditions. Farmers are thus enabled to view the different strains and get an idea as to their characteristics and adaptability to their section. The product of each plat is carefully weighed to obtain the yield; then a known amount of each kind is set aside for spring weighing so as to compute the yield of dry shelled corn of each of the strains. It has been found that there is frequently a difference of 25 bushels per acre between the highest and the lowest-yielding kind, and in some of the tests there is as great a difference as 50 bushels to the acre.

The ranking of a given strain of corn will vary more or less according to conditions—character of the season, date of planting and other factors. There is no doubt, however, that if this work is continued for a number of years it will be possible to state which are the strains having the best characteristics and the highest yielding ability for the various sections of the state. The general use of this information by farmers may easily result in a gain of thousands of dollars a year to each county. This work has proceeded to such a point in a few counties that certain strains are now definitely known to be consistently high yielders. In Camden County, for instance, there are two local kinds, a yellow and a white-cap, which have ranked uniformly high during the past three years. In that county, also, a strain of Boone County White has proved itself a high yielder on strong soil in a long season.

Four silage corn demonstrations were conducted in 1919—at the Walker-Gordon Farm, Plainsboro; Forsgate Farms, Jamesburg; College Farm, New Brunswick, and G. M. Canfield's Farm, West Caldwell. The purpose of these tests is much the same as the husking corn tests.

Potatoes

The leading problem in demonstration work on potatoes in this state continues to be the source of seed. Demonstrations covering this question were carried on in 5 counties in 1919—Burlington, Mercer, Middlesex, Monmouth and Passaic. There were 209 demonstrations in these counties and the total attendance at meetings held at the demonstrations was 857 persons.

These demonstrations have consisted of plats planted to seed from various sources—South Jersey late-crop, Virgina late-crop, northern and immature. During the past 5 years the Mercer County Office of Farm Demonstration has been quite active in promoting the home production of late-crop seed, especially of the Cobbler variety. It was estimated that in 1918 a third of the seed potatoes used in that county were from late-crop seed. Over 2,300 bushels of seed potatoes were placed in cold storage in the spring of 1919 by Mercer County farmers to be planted for late-crop seed about the first of August. The men of that county are now fairly well convinced that the production of home-grown late-crop seed, especially of the Cobbler, is good business. Late-crop Giants and Green Mountains were also grown under the direction of the demonstration office of that county in 1919.

In Monmouth County, where interest centers largely in Giants, an extensive set of demonstrations was carried out in 1919 to show the possibilities of immature seed. By this term is meant seed that is dug while the vines are green. This is generally done in late July or early August; the seed is stored in some place to dry for a few weeks and is then placed either in a good cellar or in cold storage until planting time next spring. This seed has been placed in demonstrations beside northern seed and late-crop Giant seed from Virginia and South Jersey. In 1919 about forty men planted immature seed in a demonstration way in Monmouth County. Its germination was better as a rule than that of northern seed, and the vine growth was better throughout the season. It was found that the crop from the immature seed set heavier than the other kinds, but the tubers did not average quite as large; there was a smaller proportion of grade 1 tubers, and a larger proportion of seconds. There was also more rot in the crop from immature seed. It will require several more years of work before the limitations and the possibilities of this type of seed will be fully known.

Alfalfa

Records show that six of the counties had demonstrations in 1919 on alfalfa. The total number of these demonstrations was 112; at some of these demonstrations meetings were held, the total attendance at which numbered 506. In addition to this, the county agents in 12 counties were called upon frequently for advice in the growing of the crop. Records indicate that advisory effort was extended to 836 farmers and that the total amount of alfalfa seeded as a result was 7,008 acres.

Passaic County had 30 alfalfa demonstrations in 1919. The county agent helped these men get seed and inoculated the seed by the soil-and-glue method with entire success. An alfalfa tour was held in June; some of the demonstrations were visited for the purpose of showing the crop growing on limed and unlimed soil, heavy and light soil, seeded after oats, and between fodder corn, and under various other conditions. On this tour all the requisites for success with the crop were brought out.

In Sussex County an alfalfa campaign was put on which had for its slogan, "1,000 acres of alfalfa for 1919." It may be said that this objective was attained. Government inoculant was obtained and many demonstrations on inoculating the seed with soil were given. A large part of the acreage was sown in the spring of 1919 with a nurse crop in a mixture with grass and clover. The amount of alfalfa in the mixture was usually from 6 to 8 pounds per acre. Many satisfactory stands resulted from this effort. A similar campaign was carried on in Warren County.

Soil Improving Crops

The agronomy specialist and the county agents in many of the counties expended much effort during the year in encouraging the more general use of the summer soil-improving crops, such as cowpeas and soybeans, and the winter cover crops, such as vetch, crimson clover, alsike clover, sweet clover and rye. There is no doubt that the growing of these crops is becoming more and more a regular practice of the best farmers of the state, especially in the southern sections.

In Cape May County intensive publicity efforts resulted in the sale of 3 tons of vetch seed to the farmers. The sale was effected through the Belle Plain Cooperative Association. The publicity campaign resulted in the sowing of over 2,000 acres to cover crops in the county. Rye, vetch, crimson clover and alsike were the leading crops sown.

In Bergen County the Bergen-Passaic Cooperative Association was enlisted to secure vetch seed for the farmers. An intensive publicity campaign on cover crops also was conducted in this county, with the result that 27 men purchased 1,500 pounds of vetch seed. This seed was sown after sweet corn and at the last cultivation of tomatoes and other crops.

Another cover crop campaign was conducted in Camden County similar to the one of 1918, when nearly 9 tons of cover-crop seed was

purchased by the farmers through the county board of agriculture. I 1919 the amount of seed purchased in this way was over 22 tons, c which 14 tons was vetch and the remainder crimson clover, alsik alfalfa, cowpeas and rye. Never before in the history of the count had the land been so thoroughly covered with a mat of green as durin the winter of 1919-20.

Also, in Camden County a cover-crop comparison demonstration wa put on with 10 plats seeded to the various cover crops and combination of crops. A crimson-clover strain demonstration also was conducte including 12 plats seeded with seed from various sources.

Lime

There is no doubt that a large proportion of the farms of the stat need lime. There is, also, no doubt that the general use of lime o soils needing it, followed by the general growing of clover, vetch, cow peas, alfalfa and similar crops which make the best use of lime, woul result in an addition of millions of dollars to the annual crop produc tion of the state. The agronomy specialist and the county agents ap preciate these facts and have encouraged by demonstrations and ad vices, the more general use of this great soil ameliorant. Practicall all the county agents have soil testers used in determining the lim requirement of soils. Records show that during the year there wer 1,001 soil tests made in the offices of the county agents, besides man that were made at New Brunswick.

One very helpful piece of work was carried on in Mercer County ir the way of an intensive campaign on lime. This took place in fou communities in the dairy region of the northern part of the county Samples of soil were collected by community committeemen. A meet ing was then held in each community, at which time the samples wer tested for acidity. A speaker was present at each meeting to lead th discussions on lime. Over a hundred samples of soil were tested a these meetings. Special prices on lime were made during the cam paign by the Farmers' Cooperative Association and by dealers.

The Farmers' Cooperative Limestone Company of Sussex County which the extension specialist and the county agent were instrumenta in forming early in 1919, is now doing a successful business. Lime i being supplied to local farmers at a very reasonable price.

During the year, Extension Circular 8, Lime, the Key to Soil Fer tility, was published.

Miscellaneous Activities

Besides the publication noted above, the agronomy specialist also published during the year Extension Circular 12, Home-Mixing of Fertilizer. He attended and addressed many farmers' institutes and field meetings. Records show that he made 97 visits into the counties in the interests of various demonstrations and to assist farmers with their problems. Many letters from farmers dealing with farm crops and soil-fertility questions were answered.

REPORT OF THE SPECIALIST IN POULTRY HUSBANDRY

IRVING L. OWEN

As this report covers the period from July 1, 1919, to July 1, 1920, it divides the natural poultry year which extends from November to November. The information covered by this report includes the results obtained from work done in the natural poultry year, concluding November 1, 1919, and that planned and accomplished so far in the natural poultry year that will end November 1, 1920.

The poultry extension work of New Jersey is being carried on along well-developed lines, a state project or program having been carefully made up to cover all phases of the industry and to reach all manner of poultrymen. Accordingly, the program referred to above has classified the poultry extension work into six main groups, namely:

1. The commercial poultry farm.
2. The general farm flock.
    a. The large specialized flock.
    b. The small farmyard flock.
3. The exhibition poultry flock.
4. The suburban backyard flock.
5. The boys' and girls' poultry club flock.
6. The highly specialized poultry industry.
    a. Commercial hatcheries.
    b. Capon production.
    c. Commercial broiler production.
    d. Commercial fattening establishments.

In this outline a detailed status of the various lines of poultry industry in the state has been written up and also the history of poultry extension work that has been carried on in the state. Demonstration projects have been outlined in detail following the lines of subject-matter that is being considered in the regular departmental work of the Experiment Station. This subject-matter, as far as the extension work is concerned, seems to fall naturally into the following lines:

A. Systematic Project Work:
1. The keeping of systematic records of cost of production and amount of profit.
2. The development and use of good strains of stock.
3. The elimination of the poor producer through the practice of culling.
4. The construction of proper poultry houses.
5. The use of properly-balanced rations.
6. The use of artificial illumination to insure more efficient egg production.
7. Cooperation with existing local poultry associations through the promotion of educational programs and the establishment of new associations.
8. The use of greencrops in the poultry yards.

B. General Advice:
1. Early hatching and avoiding late hatching.
2. Colony brooding and proper growing rations.
3. Sanitary methods to insure health.
4. Home-grown poultry feeds.
5. Caponizing.
6. Proper care and use of manure.
7. Home preservation of eggs.

Keeping Systematic Records of the Cost of Production and Amount of Profit

A great deal of the extension specialist's time has been taken up conducting this demonstration. Twelve cooperators started this p ject on November 1, 1919, 10 completing a 12 months' report. Th 10 men have realized the benefit and advantages of being cooperat and conducting these demonstrations and in some cases have been v influential in assisting their neighbors on various problems of poul management. This year it was the purpose of the extension specia to select poultry keepers who were especially progressive, successful a influential men in their communities. Nearly 100 cooperators w secured to carry on the work, with records being kept on over 100,(hens.

Monthly records were kept by the cooperators, the blanks being s to them a few days previous to the beginning of each month, wit stamped, addressed envelope for returning the previous month's co pleted record. These records were made out in triplicate by the sp ialist, copies being returned to the cooperator and to his county age as well as tabulated results, including all of the cooperators. T made a monthly standard on all of the costs incurred by these poult men, as well as all of the revenue, figuring each month the cost of e production and the monthly profits exclusive of interest and deprec tion. Details of these figures are given in tables 1, 2, 3 and 4.

The price per dozen eggs as given for the average farm is the act price received by the cooperator and not, as is often done, taken fr the average price on the wholesale market. The breakage of eggs the farm was a trifle under 3 per cent.

In making comparisons of the average project farm and the b project farm, one thing stands out pre-eminently. Although the ope tor of the best farm received considerably less for eggs and paid m for feed, he made $2.00 per bird more, which was made possible alm entirely by the increased egg production. Had this man received o the average price for his eggs, it would have made a difference of ov $600 on his income, or increased his labor income over 50 cents mo per bird. Also, had he purchased his feed for the average price

Average Monthly Report

	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
Number of Birds	9235	11282	10201	10970	9963	10618	9158	8832	8403	7424	7144	9231
Eggs	37445	69524	79663	100923	139826	164650	147896	124566	108141	86769	64921	45580
Per cent Production	13.5	20.4	25.2	33	45	51.7	52.3	47	41.6	37.7	30	16
PER BIRD												
Number of Eggs	4	6.1	7.78	9.17	14	15.5	16	14	13	12	9	5
Return on Eggs	31c	42c	43c	33.5c	40c	51.4c	64.5c	66c	72c	71c	58c	36c
Mash Consumed (lbs.)	2.86	2.82	3.4	3.4	3	3.5	3.8	3.4	3.8	4.1	3.7	3.1
Cost of Mash	9.8c	9.5c	11.7c	11.7c	10c	12.1c	13.7c	12c	14c	15c	13c	11c
Scratch Consumed (lbs.)	3.1	3	3.1	3.2	3	3.1	3.8	2.7	2.9	3.2	2.8	3.4
Cost of Scratch	10c	10c	9.9c	10.3c	9c	10c	14.7c	9.5c	10c	10c	10c	12c
Total of Feed Consumed (lbs.)	5.96	5.82	6.5	6.6	6	6.6	7.6	6.1	6.7	7.3	6.5	6.5
Cost of Feed	19.8c	19.5c	21.6c	22c	19c	22.1c	28.4c	21.5c	24c	25c	23c	23c
Returns over Feed	11.2c	22.5c	21.4c	11.5c	21c	29.3c	36.1c	44.5c	48c	46c	35c	13c
Miscellaneous Returns	8c	3c	3.9c	15.5c	25c	28.3c	4.7c	1c	3c	1c	1c	3c
Extra Labor Cost	1.8c	.7c	.8c	1.1c	1c	2.1c	2.4c	2c	2c	5c	6c	3c
Total Receipts	39c	49c	47.8c	49c	65c	79.7c	92c	93c	$1.05	$1.09	81c	52c
Total Expenses	25c	25.3c	27.5c	28.5c	28c	34.9c	44c	28c	35c	40c	38c	36c
Net Returns (exclusive of interest and depreciation)	14c	23.7c	20.3c	20.5c	37c	44.8c	48c	65c	70c	69c	43c	16c
AVERAGE PROJECT FARM												
Number of Birds	1026	1025	1020	997	996	965	916	883	840	742	714	923
Number of Eggs	4160	6320	7966	9175	13982	14877	14790	12457	10814	8677	7492	4558
Per cent Production	13.5	20.4	25.2	33	45	51.7	52.3	47	41.6	37.7	30	16
Feed per Dozen Eggs (lbs.)	17.6	11.4	9.8	8.63	5.4	5.2	5.7	5.2	6.3	7.5	8.6	16
Feed Cost per Dozen Eggs	60c	38.4c	32c	28.5c	18c	17.7c	21c	18c	23c	26c	27c	54c
Total Cost per Dozen Eggs	73c	49.4c	41c	37.2c	24c	26.9c	32.7c	24c	33c	41c	50c	89c
Price per Dozen Eggs	92c	82c	75c	60c	50c	52c	54.5c	56c	67c	73c	77c	88c
Returns on Eggs	$319.18	$431.39	$442.55	$334.90	$391.30	$496.27	$591.38	$580.81	$699.41	$531.40	$415.99	$337.29
Mash Consumed (lbs.)	2941	2892	3420.6	3397	2092	3372	3512	3019	3254	3030	2663	2891
Cost of Mash	$100.86	$96.88	$117.28	$116.90	$99.10	$116.87	$125.53	$105.72	$120.26	$112.86	$97.35	$103.23
Cost of Mash per cwt.	$3.43	$3.35	$3.43	$3.44	$3.31	$3.46	$3.57	$3.50	$3.70	$3.72	$3.65	$3.58
Scratch Consumed (lbs.)	3175	3099	3071	3199	3335	3057	3535	2387	2420	2389	1986	3218
Cost of Scratch	$106.68	$105.28	$99.66	$103.11	$102.92	$102.87	$134.32	$84.61	$86.70	$86.40	$71.61	$114.01
Cost	$3.36	$3.40	$3.24	$3.22	$3.08	$3.36	$3.80	$3.54	$3.60	$3.20	$3.61	$3.54
Total Feed (lbs.)	6116	5991	6491	6597	6327	6427	7047	5406	5674	5419	4649	6109
Cost of Feed	$207.54	$202.16	$216.94	$220.01	$202.02	$219.77	$259.85	$190.33	$206.97	$189.26	$168.96	$217.24
Cost of Feed per cwt.	$3.39	$3.37	$3.34	$3.33	$3.19	$3.40	$3.68	$3.51	$3.64	$3.50	$3.63	$3.55
Returns over Feed	$109.22	$231.71	$217.07	$106.88	$206.00	$265.18	$331.59	$389.48	$377.78	$329.02	$231.56	$120.05
Table Poultry Sold	$1.65	$9.28	$9.80	$9.90	$4.62	$14.67	$22.97	$129.52	$68.88	$119.28	$24.86	$10.79

Table 1—Continued

Average Monthly Report

	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
ching Eggs Sold	....	....	....	$73.23	$99.75	$69.08	$17.75	$5.43	....	....	....	....
Chicks Sold	....	....	....	....	$96.00	$179.92	....	....	....	....	....	....
k Sold	$78.00	$2.13	$10.06	....	....	....	....	$83.96	$86.31	$141.13	$122.17	$81.21
rn on Manure	$1.05	$2.87	$3.13	$9.23	$14.49	$0.40	$8.93	$14.17	$5.20	$0.80	$2.92	$21.20
ellaneous Returns	$2.64	$17.00	$39.28	$15.95	$31.14	$10.38	$43.26	$7.34	$24.18	$6.68	$9.47	$24.88
a Labor	$17.00	$8.00	$8.98	$11.03	$8.84	$20.82	$22.37	$17.56	$19.33	$39.52	$43.83	$29.72
ght and Express	$5.00	$5.23	$5.00	$4.84	$13.35	$8.05	$6.49	$4.64	$6.43	$4.05	$2.98	$3.90
k Bought	....	$2.20	....	$7.47	....	....	....	....	....	....	$7.72	$17.95
ellaneous Expenses	$22.40	$37.63	$42.25	$34.60	$46.18	$56.20	$104.50	$25.24	$48.32	$48.14	$33.09	$49.69
l Returns	$400.96	$462.59	$481.84	$490.52	$637.30	$770.68	$840.70	$821.16	$883.98	$811.43	$575.40	$475.37
l Expenses	$254.31	$259.40	$273.17	$285.03	$279.84	$335.47	$403.08	$250.62	$295.71	$296.03	$271.53	$318.50
Returns (exclusive of interest and depreciation)	$146.65	$203.19	$208.67	$205.49	$357.46	$435.21	$437.62	$570.54	$588.27	$515.40	$303.87	$156.87
cent Mortality	0.3	0.5	1	0.8	2	1.3	1.3	1.1	0.1	0.7	2	0.4

Table 2

Records of the Best Farm Compared with Those of the Average Farm

	Best Project Farm	*Average Project Farm*
Number of Birds	992	970
Number of Eggs	172985	115268
Per cent Production	48	34.4
Feed per Dozen Eggs (lbs.)	6	7.5
Feed Cost per Dozen Eggs	22.8c	26c
Total Cost per Dozen Eggs	29c	36c
Price per Dozen Eggs	57.3c	61.9c
Returns on Eggs	$7,788.98	$5,571.85
Mash Consumed (lbs.)	53450	37384
Cost of Mash	$2,033.89	$1,303.84
Cost of Mash per cwt.	$3.80	$3.48
Scratch Consumed (lbs.)	33100	34861
Cost of Scratch	$1,256.43	$1,198.17
Cost of Scratch per cwt.	$3.80	$3.45
Total Feed (lbs.)	86550	72245
Total Cost of Feed	$3,290.32	$2,502.01
Total Cost of Feed per cwt.	$3.80	$3.46
Return over Feed	$4,498.66	$2,915.54
Table Poultry Sold	$31.63	$426.29
Hatching Eggs Sold	$472.64	$265.24
Baby Chicks Sold	....	$275.92
Stock Sold	$1,224.11	$605.81
Return on Manure	$402.90	$84.39
Miscellaneous Returns	$192.15	$422.52
Extra Labor	$317.30	$247.00
Freight and Express	$146.69	$69.96
Stock Bought	$60.00	$35.34
Miscellaneous Expenses	$376.91	$568.38
Total Returns	$10,112.31	$7,651.93
Total Expenses	$4,191.22	$3,422.69
Net Return (exclusive of interest and depreciation)	$5,921.09	$4,229.24
Per cent Mortality	2.5	12.3

Per Bird

Number of Eggs	174	126
Return on Eggs	$7.85	$6.08
Mash Consumed (lbs.)	53.9	41.5
Cost of Mash	$2.05	$1.44
Scratch Consumed (lbs.)	33.3	37.3
Cost of Scratch	$1.26	$1.25
Total Feed (lbs.)	87.2	78.8
Total Cost of Feed	$3.31	$2.69
Returns over Feed	$4.54	$3.39
Miscellaneous Returns	$0.20	$0.97
Extra Labor Cost	$0.32	$0.28
Total Receipts	$10.20	$8.62
Total Expenses	$4.22	$3.90
Net Return (exclusive of interest and depreciation)	$5.98	$4.68

paid in the state, he would have saved or added to his labor income about $300. This price of eggs and price of feed together would have meant a little short of $1,000 on a few more than 1,000 birds, or would have made a difference of about $1.00 per bird. This shows that one

Table 3

Best Farm Balance Sheet

Inventory as of November 1, 1918		
Land, 5 acres	$1,000.00	
Buildings	3,335.00	
Equipment	535.00	
Implements and Machinery	103.00	
Incubators and Brooders	350.00	
Stock (1075 birds)	2,700.00	
Inventory as of November 1, 1919 (increased Number of Birds 286, improvements installed and extra feed)		$8,803.00
Total Operating Expenses (exclusive of interest and depreciation)	4,191.22	
Interest on Investment at 4 per cent	319.32	
Depreciation at 5 per cent	399.15	
Total Income (exclusive of invested income)		10,112.31
	$12,992.69	
Labor Income (1075 Birds)	5,922.62	
	$18,915.31	$18,915.31
Labor Income per Bird	$5.51	

Table 4

Average Project Farm Balance Sheet

Inventory as of November 1, 1918		
Land, 32 acres	$3,466.67	
Buildings	5,923.00	
Equipment	675.00	
Implements and Machinery	125.00	
Incubators and Brooders	406.50	
Stock (970 birds)	2,271.00	
Inventory as of November 1, 1919 (increased number of birds, 80 improvements installed and extra feed)		$13,438.97
Total Operating Expenses (exclusive of interest and depreciation)	3,401.55	
Interest on Investment at 4 per cent	510.68	
Depreciation at 5 per cent	643.35	
Total Income (exclusive of invested income)		7,373.74
	$17,422.75	
Labor Income (970 Birds)	3,389.96	
	$20,812.71	$20,812.71
Labor Income per Bird	$3.50	

cannot be too careful in buying and selling, but that by far the deciding factor in profitable egg production is the average production per bird.

Another interesting matter in the comparison of these figures is the proportion of mash feed to scratch in the best record and in the average. In the best we see about 60 per cent more mash feed than grain, while in the average record there is only 10 per cent more. In report-

ing this project for last year, these very same comparisons were found between the best and the average reports.

Besides a better method of feeding as used by the man with the best egg production, the other influences which were pertinent in affecting his egg yield are: first, abundant alfalfa ranges for his young stock as well as the laying flocks; second, the fact that his pullets last fall were in the best of condition, ready to go into the winter with plenty of flesh reserve; third, detailed care and attention to his layers at all times, especially during the fall and winter; fourth, careful attention in breeding and selection, with both the trap nest and modern methods of selection.

As previously stated, this project was started on a still larger scale on November 1, 1919, with over 100,000 birds under test. Because of various factors, especially the lack of labor, many of the cooperators gave up the keeping of detailed records. A considerable number, however, especially in Bergen, Camden, Passaic and Cape May counties, are still following this work in minute detail, and at the end of the year it is hoped that summaries can he made to show as good results as have formerly been the rule. It is with these cooperators that many other lines of work are possible, such as culling, artificial illumination, house construction, and through them that the lessons learned are taught to poultrymen in their immediate vicinity.

The Development and Use of Good Strains of Stock

During the fall of 1919 there were 120 pedigreed White Leghorn cockerels distributed throughout the state. In most cases the arrangements were made through the county agents, they handling the publicity and securing the cooperators. No report can be made of results of this project as yet. At a later date, when it has been possible to study the performance of the progeny from these cockerels, data will be obtained as to the fertility and hatchability of eggs, quality of chicks, development of pullets during the growing season, and egg production after maturity.

During the spring of the present year there were 33,000 hatching eggs shipped to various poultrymen throughout the state; the procedure was the same as in the case of the cockerels, the county agent arranging for the men to whom the eggs were shipped. Here, again, reports will be obtained at a later date, on the results of the use of this stock. Both the cockerels and hatching eggs are from the best stock at the Experiment Station, resulting from work that has been carried on through several years in obtaining a strain of high-producing birds. This extension project has been carried on for the last two or three years and comments from poultry extension men and investigators from other states and Canada are very favorable as to the results which they have observed while traveling through New Jersey as to the effect and influence that this stock has had in improving the general stock through-

out the state. A fee covering the cost of raising and pedigreeing these males was charged, amounting from $3.00 to $5.00 each. The hatching eggs were sold at the average price then received by commercial poultrymen, so that those receiving the eggs were able to obtain them at reasonable prices, considering the quality of the stock.

The Elimination of the Poor Producer Through the Practice of Culling

The art of studying the ability of a fowl to produce eggs, as evidenced by the body formation and pigmentation, has been established only in recent years. There is no doubt but that it is one of the most important facts recently established, working toward the improvement of the poultry industry. This state has taken a leading part in the development of this work, and it has been a part of the extension program for the last three or four years so that throughont the state leading poultrymen are culling their flocks, resulting in an increase in the percentage of egg production, as well as an immediate saving through marketing the non-producer. Through the summer of 1919 there were many demonstrations given on the art of culling, the procedure being to arrange with the county agents for meetings at which the poultry specialist would explain the details of the method, using typical specimens from the flock to illustrate the subject, culling several of the birds himself, and then having the interested members of the audience carry on the work under his supervision. This year several demonstrations have already been given at meetings of various sorts and a large number have been arranged for July and August throughout the state, including evening lectnres and demonstrations at tours and other large summer meetings.

The Construction of Poultry Houses

There has been a general call for aid in the construction of various types of poultry houses, especially in laying houses which follow the general plan of the New Jersey multiple unit house. About two dozen blue-prints have been furnished to men contemplating the building of new houses and a large number of circulars which contain plans have been sent out. In a number of cases the poultry specialist has made personal visits, given advice on the entire laying out of the plant and suggesting the remodeling of houses to conform to the specifications contained in the cirenlars. At present there seems to be a tendency toward the increasing of poultry farms in the state, and in the majority of these cases the buildings being erected are either exact reproductions of the New Jersey house or it is the general type with slight modifications. While this tendency is widespread, it is par-

ticularly noticeable in Ocean County in the region of Toms River. While the type of buildings in these sections has been influenced to a large degree through direct contact with the Experiment Station, the extension activities carried on during the past years have contributed largely toward the construction of a standard type of buildings.

Use of Properly Balanced Rations

Twelve cooperators have been using the rations as outlined by the Experiment Station and at the Vineland Egg-Laying Contest. In all cases the records of egg production secured by these cooperators have shown an increase of around 20 per cent, with a general decrease of about 5 per cent in the cost of feeding. In addition to this a large number of feeding circulars have been issued from the office and the specialist is constantly receiving letters from the recipients expressing their satisfaction in the use of the rations recommended.

Table 5

Results of Artificial Lighting of Poultry Houses

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Number of Flocks	14	14	14	14	14	14	14
Number of Birds	3,940	3,940	3,940	3,371	3,878	3,745	3,802
Number of Eggs	*35,463*	*45,190*	*53,188*	*39,771*	*52,896*	*54,003*	*280,511*
Per cent Production	30	37	45	38.06	44	51.5	41
Average Per cent Production for State where no *Lights were Used*	26	13	15	20.4	25	33.3	22
Increased Egg Production Due to Lights	5,051	30,312	35,458	15,686	22,601	18,050	127,158

The Use of Artificial Illumination to Insure More Efficient Egg Production

The lighting of laying houses during the winter months to increase egg production has attracted more interest throughout the state than any other new practice of recent years. This has been taken up rapidly by all manner of poultry keepers, even to those having small flocks in urban districts. It is estimated that 20 to 25 per cent of commercial poultrymen in intensive centers of production used artificial lights during the past winter. Careful records were kept with 14 cooperators, the results being given in table 5.

The results show somewhat less than double egg production due to lights, and when eggs are figured in dollars and cents, show four times the net returns over the cost of feed and lights in the lighted pens. These flocks as a whole showed a much better condition of health, etc., than did the birds not under lights, and, although in most pens the lights were discontinued by April 1, the hens continued to lay about the same number of eggs as the birds which had not been under lights.

The practice of artificially lighting hen-houses has shown without a shadow of a doubt that it will materially increase fall and winter egg production and has very little, if any, influence on the egg production of spring and summer which follow. It has also been shown that it is not a forcing or so-called burning up of the hens, but is rather giving the hens an opportunity to do not only what they should, but also what they seem to be anxious to do.

In addition to obtaining these records the poultry specialist has given much personal and written advice on the subject as to equipment, time of lighting and proper feeding. Through study of individual cases and attendance at local poultry association meetings where this subject was taken up, important data have been secured that will make possible answering certain vital problems that have arisen through the use of artificial illumination. Plans are under way whereby this project can be carried on in greater detail the coming winter, and with the knowledge now at hand it will be possible to carry on this work with greater accuracy and a greater assurance of success.

Cooperation

The poultrymen of New Jersey are organized as in no other branch f the agricultural industry. Practically every county in the state as one or more active poultry organizations carrying on regular ionthly meetings with excellent educational programs. These assoiations make a heavy call upon the poultry specialist in attending egular meetings and taking part in the program. It is through these rganized meetings, however, that the specialist is able to meet large umbers of active poultrymen and to gain their help in taking up the rious projects in the extension work. In many of the counties these sociations are active in the support of extension activities, giving ieir support to the work of farm demonstration, home demonstration id the boys' and girls' clubs that may be carried on in their counties. seems possible that through closer cooperation between these organitions and the extension activities that the subject-matter of the exnsion program may be placed before the poultry interests in a maner that could in no other way be possible. It is the plan of the ecialist, as time goes on, to make this cooperation more nearly unirsal, in order that the organized poultry interests of the state may dorse and assume some responsibility toward carrying on the poultry

program throughout the state. During the past year the poultry specialist has assisted in the formation of four new poultry associations, namely, in Camden, Burlington, Gloucester and Bergen counties. In all cases the county agents of these counties have given able assistance and are active as officers or members of executive committees. There are several sections in the state that are still unorganized and plans are under way whereby as soon as the unity and interest are sufficiently strong, organizations will be immediately effected.

The Use of Green Crops in the Poultry Yards

In certain sections of the state there is much need of a system of growing green crops in poultry yards and ranges, while in individual cases throughout the state the lack of proper green crops is a handicap to the poultryman. Considerable information is given in individual cases through personal contact and written information. In addition to these there were 6 cooperators who have been raising alfalfa and rape on their ranges, following instructions furnished by the specialist. In all cases the results have been very satisfactory, the mortality of the growing birds being less by 10 per cent, a remarkable even growth being secured, and the egg production being greater as compared with the results from previous years.

Early Hatching and Avoiding Late Hatching

It is an established fact that to secure good winter egg production, the chicks must be hatched early enough to mature before cold weather and that more vigorous chicks can be brooded before the hot weather sets in. A great deal of advice both by personal contact and written data is given relative to hatching chicks early enough to avoid bringing off hatches so late as not to have matured birds before cold weather, as well as to avoid brooding in hot weather. During the spring of 1919 this work was carried on with 9 cooperators. The records obtained show that the returns from cockerels which were sold as broilers from the early hatches amounted to double the returns that were received from broilers hatched in late April and early May. The hatches, although about 12 per cent less than later in the season, gave a great deal better brooding record, running from 5 to 10 per cent lower in mortality. The earlier hatched birds also showed a greater average vigor than the late-hatched, and the advantage of the early hatching was shown in high production from these same birds during the past winter.

As a general proposition early hatching has been accepted as that occurring in the month of February, medium hatches in April and fairly late hatches in May, with the first of June as the limit. Feb-

ruary pullets usually begin laying in August, making possible the use of these eggs to fill in the gap caused by the moulting of the regular flock. The February pullets usually go through a moult in late fall and can be used for breeders in the spring, being about as good as yearlings. April hatches produce pullets that are average birds, maturing in October and with proper care lay well throughout the winter. These pullets should make up the greater portion of the laying flock. Some of the poultrymen are practicing the hatching of both February and April birds to insure a constant egg supply for their trade.

Colony Brooding and Proper Growing Rations

The brooding and feeding of young stock is one of the most exacting phases of the poultry industry. It is often the case that future production depends upon how successful a man is in raising his pullets. There are many questions arising constantly in brooding and proper feeding, and an effort has been made to meet these wherever they arise by both visits to the farms in question and the placing of written data in the hands of the individuals needing the aid. The specialist has visited a considerable number of poultry farms where colony-brooding systems have been laid out and the owner induced to adopt the standard growing rations of the department. In six cases the specialist has given advice relative to the changing of the long brooder system to colony houses, and close touch is being kept with the owners in order that the results may be obtained and publicity be given as to results for the coming season.

Sanitary Methods to Insure Health

The specialist is often called upon to inspect poultry plants at which certain diseases are prevalent. Advice has heen given as to methods to insure health and to correct the immediate condition. This has been found especially true in cases of chicken pox, roup and canker, and considerable data have been collected bearing on the possible causes of serious epidemics. A circular is being prepared on the subject of interior house construction that may help in the prevention of these diseases. This circular will be issued before the coming winter and a study of results made with the cooperators.

Advice has been given in several cases relative to the home growing of certain poultry feeds. These cases have arisen in most places where the poultryman has a relatively large area of land or has a general farm flock. With feeds at their present prices the growing of some of the grains has added materially to the profits of the flock.

Caponizing demonstrations have been held at several places, one being on the occasion of the Mercer County Boys' and Girls' Poultry Club tour held June 12.

The manure obtained in the keeping of a large flock of poultry is a valuable asset. In some sections of the state where there is a demand for this material among truck growers, it may run into hundreds of dollars. Thus its care and preservation becomes of considerable moment. Advice has been given relative to the proper sort of storage building and the use of preservatives, especially acid phosphate.

Preservation of eggs by the water-glass method, while of the greatest interest during the war, is still calling for a considerable amount of attention. Directions for this method have been issued in a great number of cases during the past spring. This work will be carried on largely in the future through the home demonstration agents in the various counties and thus bring the matter nearer to the householders throughout the state.

The greater part of the work referred to in this report was accomplished by Victor G. Aubry, who resigned his position as extension specialist in poultry husbandry on March 1, 1920, his place being taken by the writer. Most of the records referred to in this report were compiled by Mr. Aubry, the writer having gathered them together from various sources. Much of the time since March 1 has been devoted to the formulation of plans and establishing contact with the county agents, local poultry associations and individual poultrymen. Up to the present time much of the poultry extension work has beeu done through the county agents or directed from the specialist's office. Plans are now in process of formulation whereby such phases of the state-wide project as are adaptable shall be carried on through cooperation with the home demonstration agents and boys' and girls' cluh leaders. Home demonstration agents and club leaders will adopt a plan of work written up in project form, this form to be along broad lines, covering nearly every phase of the industry.

One especial aim of the project with the home demonstration agents will be to reach the farm flock through securing demonstrators among the farm women. There are, at the present time, several boys' and girls' clubs in the various counties having club leaders, and the specialist is cooperating with the work of these clubs. Through the new program being contemplated, a much closer relationship will be established, and through the form and plan of the project it is hoped that the work may be carried on with even greater success than is now the case, and with a wider scope as far as the territory and the number of clubs is concerned.

REPORT OF THE SPECIALIST IN DAIRY HUSBANDRY

JOHN W. BARTLETT

Dairy extension work in general during the year 1919-20 has progressed very well. All of our cow-testing associations that were existing a year ago are now going, and three new associations have been started during the past year. The work has been carried on in all of the dairy counties.

In December, 1919, Stanley B. Roberts, who was acting as cow tester for the Delaware Valley Cow-Testing Association, was taken on as assistant dairy specialist. Mr. Roberts has spent practically all of his time in supervising the cow testers in their work with the associations. One of the striking things regarding our cow-testing associations is that at one time during the past year we had 7 men with college training as testers. The dairymen of the state are realizing more and more the value of cow-testing association work. The work of the extension specialist has changed more or less during the past year as regards the organization of cow-testing associations. In the past new members were secured through personal visits by the county agents and specialist in addition to association members, but during the past year our associations have in many cases been kept with a full membership through the efforts of the members of the organized associations alone. In the case of the Flemington Association, the only work done by the specialist in organizing the community was a visit to Flemington to help draw up a constitution and by-laws at the time of the first organization meeting.

Another indication of the attitude of the farmers of the state toward combining efforts has been demonstrated by the great interest taken by the different breeders' associations of the state, especially among the Holstein men. The Holstein breeders have fostered the efforts to bring about advertising, sale of surplus stock, and the promotion of better dairying, both as local groups and as a state association. The dairy specialist has followed the policy outlined and agreed upon throughout the extension force, and is cooperating with the county agents and their executive committees in outlining county-wide programs of work. It has been the aim not only to bring together in an organized and demonstrational way better methods of dairying, but to look into the future as well, and by county-wide outlines govern the promotion of dairying and its products for a period of years. In this line the specialist has suggested six major projects for the year 1919-20, and the dairy extension work has been carried on under these projects. They are:

1. Cow-testing associations.
2. Calf-feeding demonstrations.
3. Dairy-feeding demonstrations.
4. Bull associations.
5. Local and state breeders' associations.
6. Junior dairy club work.

Some time has been spent each month also on state institution work in cooperation with the farm supervisor of the State Department of Institutions and Agencies.

A new association in Morris and Essex counties will start operation July 1.

Sussex County

Perhaps the most striking event in the Sussex County associations has taken place in the Delaware Valley Association. This association was organized and started in the spring of 1919. It is located on the western border, and is separated more or less from the rest of the county by mountains.

The dairymen of the towns of Montague, Layton and Walpack Center are keepers of small herds of cows. There are a few pure-breds, but the general run of cows are grades. One of the first activities of this association was the organization of a bull association at Layton, in which 7 men cooperatively purchased 3 pure-bred Holstein herd sires. The cow tester in this community was instrumental in bringing into one herd 23 pure-bred calves from a nearby county in New York State. Following this work, he selected a pure-bred herd sire for the same purchaser. Since the organization of this group of dairymen, 25 pure-bred females have been purchased, 10 pure-bred Holstein herd sires have been brought in, and are being used by 19 of the original 24 men who are charter members of the association. In one case the tester reports that he saved one dairyman enough money the first month by giving him a balanced ration to feed his cows, to pay for the association dues for the year. This association, together with the other two in the county, held a tour on June 14 of this year to Warren County for the purpose of studying the pure-bred cattle in

another section. Following is a summary of the records of the first year of the Delaware Valley Association:

HERD LETTER	No. of Cows	Lbs. of Milk	Lbs. of Fat	Cost of Feed
N	11	4211	197	$115.20
T	7	4480	164	82.20
D	5	5272	254	76.93
O	10	5960	219.5	114.59
J	16	5972	228	99.60
B	13	6565	257	96.00
M	9	6491	249	115.72
P	13	6640	256	123.50
X	9	6780	251	89.92
O	15	7612	280	158.10
V	12	7614	255	92.26
K	14	8055	292	146.50
S	22	8015	239	139.10
A	12	8141	312	122.70
L	7	8588	310	106.40
R	6	8622	272	80.31
G	11	8717	331.9	149.33

Association Average: 6,885 lbs. of milk, 257.8 lbs. of fat.

COMPARISON OF TWO HERD AVERAGES

HERD LETTER	No. of Cows	Lbs. of Milk	Lbs. of Fat	Cost of Feed	Profit	Lbs. of Feed Fed
O	15	7612	280	$158.10	$114.00	3342
V	12	7614	255	92.26	161.50	2210

Herd O was fed 1 lb. of grain to 2.02 pounds of total feed.
Herd V was fed 1 lb. of grain to 3.02 pounds of total feed.

The above shows the disadvantage of over-feeding.

Number of cows showing production of:

12,000 pounds or over	2
10,000-12,000 pounds	14
9,000-10,000 pounds	13
8,000- 9,000 pounds	23
7,000- 8,000 pounds	52
6,000- 7,000 pounds	28

A Mercer County Experiment

The Mercer County Association, now in its fourth year, has accomplished considerable. Those members who purchased pure-bred cattle in Michigan in the spring of 1919 are well pleased with the stock that was brought in. In the fall of 1919, this association cooperatively purchased a carload of cottonseed meal. The association has taken on two of the state institntions in the county, and the superintendent of these farms where the tester spends 4 days each month, has made the statement that the association work has shown them some things that they had not learned from daily milk records. During Agricultural Week, at Trenton, in 1920, four pure-bred cows were brought in to show the value of records and the value of the use of a proven sire. In this case, two cows and their two daughters, the first daughters of a herd sire to freshen, were shown as an exhibit. In one case, a pure-bred cow showed a record of 13,580 pounds of milk in one year's time. Her daughter had a semi-official record as a 2-year-old of over 14,850 pounds of milk in a year.

Results in Somerset County

The Somerset Association was fortunate during the past year in securing a college graduate as tester. This tester gave much of his time to work with the Holstein breeders who were members of his association. It is interesting to note that in the Raritan Farms' herd, a comparison was made of daily records and cow-testing association records in a year's time. There is a variation of 1.9 per cent in the two methods of keeping records. Following is a summary of the records of 12 members who were in the association a full year:

HERD	Average Production Lbs.	Number of Cows	Lbs. of Fat	Cost of Feed
T	7351	15	291	$190.50
Q	6812	11	237	123.80
B	11239*	7	365	167.50
C	9680	10	317	168.40
F	8463	18	273	127.
E	7363	14	267	126.50
D	8629	8	298	162.50
K	7502	17	275	112.00
G	7122	11	249	146.50
S	7377	30	255	196.50
O	6987	13	248	125.

*Best herd average.

The association shows the difference between cows as follows:

Herd T, High Cow (Grade Holstein), 2 years old, 11,887 lbs. milk, 4.4 per cent, 525 lbs. fat, cost of feed, $260.
Low Cow (Grade Holstein), 2 years old, 5,211 lbs. milk, 3.5 per cent, 188 lbs. fat, cost of feed, $169.
Difference, 6,676 lbs. milk, 337 lbs. fat, cost of feed, $91.
Herd C, Christmas Heng, Joh., 15,600 lbs. milk, 510 lbs. fat, high cow.
Herd F, Roxy (1) 11 years old, 8,519 lbs. milk, 3.7 per cent, 315 lbs. fat.
Roxy (2) 6 years old, 9,998 lbs. milk, 3.4 per cent, 372 lbs. fat.
Roxy (3) 5 years old, 10,030 lbs. milk, 3.0 per cent, 305 lbs. fat.

Note difference in production and fat of three daughters of one cow and *different sires.*

Number of members listed	11
Number of cows completing year since last tester started	165
Number of cows above 10,000 lbs. of milk	25
Number of herds having cows above 10,000 lbs. milk	(7)
Number of cows 9,000-10,000 lbs. milk	14
Number of cows 8,000- 9,000 lbs. milk	37
Number of cows 7,000- 8,000 lbs. milk	23
Number of cows 6,000- 7,000 lbs. milk	21
Number of cows 5,000- 6,000 lbs. milk	18
Number of cows under 5,000 (all ages) lbs. milk	27

Number of cows over 10,000 lbs. milk—22 pure-bred, 3 grade.
Number of cows over 9,000-10,000 lbs. milk—12 pure-bred, 2 grade.

Activity in Salem County

The Salem Association, started in 1913, still has 12 of the original members. Some of those that have discontinued the work during that time have recently come back into the association again. Some of the things that this association has accomplished during the past year are as follows:

Each member has fed a balanced ration. These men have carried on official testing and two 30-pound records have been made. Two of the members are now doing semi-official work, and there has been among the members of the association an increase of 70 per cent in official testing over that of 1918 and 1919. During the coming year, eight more men will carry on advanced registry work. A community testing barn has been established, where four breeders have taken their cows to be tested officially. A bull association has been organized, and 3 aged bulls saved from being slaughtered. The tester was influential in getting one man to buy a proven herd sire. Since the purchase of this herd sire, one of his daughters has made 18 pounds of butter as a 2-year-old. One herd has been placed on the accredited list, and several have been tested under the Federal accredited herd plan. Four hundred and thirty-two of the 500 cows in the association are now pure-bred. Comparing an average of the association in its first year, 1913, with the average in the year 1919, there has been an increase in

production with 500 cows in the association, owned among 18 members, of over 1,500 pounds of milk and 49 pounds of fat per cow. This increase, figured at the rate of $3.00 per hundred pounds for milk, is $23,820. Following is a summary of the association average in 1913 and 1919:

	Lbs. of Milk	Test Per cent	Lbs. of Fat	Value	Cost of Roughage	Cost of Feed	Total Cost of Feed
1913, 574 cows.	5765	3.91	225.9	$114.00	$35.81	$26.62	$62.43
1919, 500 cows.	7353	3.62	274.4	306.26	69.38	76.27	145.65
Gain	1588		48.5	$191.64			

Bull Association Work

Because New Jersey has on the average a good percentage of pure-bred bulls, it has been more or less difficult to organize a bull association. The first bull association in the state, however, was organized among the state institutions. Eleven pure-bred bulls are now owned cooperatively among 8 institution farms. The organization has been divided into three units, and each unit into three blocks.

The State Asylum at Trenton, the State Asylum at Morris Plains and the Village for Epileptics at Skillman, will make up the unit 1, and will own cooperatively 5 pure-bred bulls. The State Reformatory at Rahway, the State Reformatory for Women at Clinton, and the Sanatorium at Glen Gardner are blocks of unit 2. The Bordentown Industrial School, the State Home for Feeble-Minded at Vineland, and the Prison Farm at Leesburg are blocks of unit 3. The sires within each unit will be transferred from one block to the other each two years. Seven pure-bred bulls have been purchased for these farms at a price averaging above $500.

The Layton Cooperative Bull Association was the second one to be organized, and was started through the efforts of the cow tester in August, 1919. The officers and directors of this association are:

President, **Porter Layton, Layton.**
Secretary, **Will Clark, Layton.**
Arlie Major, Layton.
Ross Major, Layton.
Peter Major, Layton.
E. Rosencrans, Layton.

Another association, known as the Salem County Bull Association, was organized through the efforts of the cow tester in the spring of 1920. In this association, 3 farms will have the services of 3 different herd sires. In this association new bulls were not purchased, but the old bulls which had passed their usefulness on each farm have been transferred through an agreement from one farm to another. The next transfer will be made in 1922. In this case this association saved some good bulls from being disposed of. The officers and directors of the Salem County Bull Association are as follows:

President, Joseph Morgan, Yorktown.
Vice-president, J. Howard Johnson, Yorktown.
Secretary, Miss Jessie Colson, Elmer.
J. D. Graf, Yorktown.

The fourth association was organized in the Preakness Valley section of Passaic County on June 1. The officers and directors of the Passaic County Association are:

President, Nicholas Cassidy, Paterson, R. F. D.
Vice-president, Arthur Whyman, Paterson, R. F. D.
Secretary-Treasurer, Red. Day, Paterson, R. F. D.

Efforts are being made to start more bull-association work in Salem and Cumberland counties. It is also planned that this type of work will go into Burlington and Hunterdon counties very soon. There is a strong sentiment toward this type of organization already.

Breeders' Associations

The Holstein-Friesian Associations

The Holstein-Friesian organization was confined to the state association until the fall of 1919 when a move for local clubs came from Somerset County. The county agent called together a group of 5 men to talk over the possibilities of a local Holstein-Friesian Association of Hunterdon and Somerset counties. These men felt that through an organized club, dairying could be promoted, sales of surplus stock could be held, collective advertising could be carried on, and better legislation could be accomplished in that section. Following this meeting a letter was sent out to 35 breeders, calling their attention to a meeting to be held at a near date. Practically all of these men were in attendance at the meeting. When the proposed club was mentioned and its advantages given, there was a unanimous vote for the association. Following the organization of this association, the Warren County Association adopted a constitution and by-laws; then came Salem and Cumberland with an association; Mercer County with a fair-sized organization, and finally Morris County with a very enthusiastic group of breeders.

Prof. W. M. Rider, director of the National Holstein-Friesian Association, spent a week in the fall of 1919 helping to round up these local organizations. The Warren County Association has held two

consignment sales. The Somerset-Hunterdon Association held its first semi-annual sale at the College Farm at New Brunswick on March 19. Each of these local associations have adopted a program for the year and a number of projects to be carried out. All of the clubs have held meetings and have had speakers on subjects of preparing cattle for test, preparing cattle for the show ring, judging and feeding. Four of the associations are planning to send a show herd to the Inter-State Fair at Trenton in September of this year. Perhaps one of the most constructive projects is the one that is being adopted by the Somerset-Hunterdon Association. This association will start in the fall of 1920 to place all of the herds in the association on the tuberculosis accredited free list. They plan to have a community farm, and the cows worth while that react to the tubercular test will be kept on this farm until their usefulness has passed.

The Salem and Cumberland County Association has carried out an organized effort which is well worthy of mention. This association, with a membership of 80 pure-bred breeders, has recently engaged a paid secretary whose duties will be to look after purchases and sales of pure-bred stock for the association. He will conduct local sales of pure-bred bulls and will receive a salary, plus a percentage on sales and purchases.

The local associations have voted to make a strong State Holstein-Friesian Association. The presidents of each of the local associations are known as the Executive Committee of the State Club. These men have met and drawn up a constitution and by-laws, and have adopted a program of work covering the Holstein activities of the state.

Mercer County Holstein-Friesian Association:
- *President*, DeWitt Green, Lawrenceville.
- *Secretary-Treasurer*, Mrs. H. C. Scudder, Trenton Junction.

Morris County Holstein-Friesian Association:
- *President*, L. F. Castle, Long Valley.
- *Treasurer*, John C. Welch, Long Valley.
- *Secretary*, Harold S. Ward, Morristown.

Salem-Cumberland Holstein-Friesian Association:
- *President*, Walter Garrison, Roadstown.
- *Vice-president*, S. P. Ridgway, Salem
- *Secretary-Treasurer*, A. B. Bullard, Salem.

Somerset-Hunterdon Holstein-Friesian Association:
- *President*, John Tine, Lebanon.
- *Secretary-Treasurer*, Peter P. Van Nuys, Belle Mead.

Warren County Holstein-Friesian Association:
- *President*, Ernest Race, Belvidere.
- *Secretary-Treasurer*, Arthur Parr, Belvidere.

Guernsey Breeders' Associations

The Guernsey breeders of the state are anxious to become well organized. The state association has been active in the past, but feels that local clubs will strengthen this organization. A meeting was held early in the spring of 1920 to talk over plans for organizing clubs in different sections of the state, and it was felt that possibly four local

clubs can be started, one in the vicinity of Hunterdon County, one in the vicinity of Morris, one in Burlington, and one in the South Jersey district. Definite plans in regard to the organization of these local clubs have not as yet been perfected, but such plans will be carried out in the fall of 1920.

Calf Club Work

During 1919 the specialist in dairy husbandry did not devote much time to calf club work, but beginning in 1920, calf club work was made a part of the dairy extension program, and with the increase in county club leaders, the dairy specialist has drawn up in dairy counties a county outline in which Junior Dairy Club Work has a permanent part. Some time has been spent with the club leaders in Morris, Mercer, Warren, Salem and Cumberland counties, and at the present time there are calf clubs in each of the above counties as well as in Sussex, Hunterdon and Ocean counties, which have been visited frequently. One good feature of the club work this year is that practically all of the club members are raising pure-bred heifer calves. The breeders' associations have fostered this work, and have cooperated in locating pure-breds for the boys' and girls' work.

State Institution Work

The extension specialist has cooperated with the supervisor of state farms, giving an average of one day a month to this type of work. Although during 1919 the State Institutions' Cooperative Bull Association was formed, not until this past year were the different blocks permanently organized. Details concerning the blocks have been given above.

One very creditable accomplishment in the dairy work among the state institutions is the fact that through the cooperation of these farms in tuberculosis eradication, 8 of the 11 farms have now received certificates placing their herds on the tuberculosis-free accredited list.

Three of the state institutions have become members of cow-testing associations, and three more are on the waiting list to join associations in their territory.

Calf-Feeding Work

The use of the home-mixed calf meal has been carried on during the past year with demonstrations in the following counties: Mercer, Sussex, Bergen and Salem. Each of the calf-club members during this year are classified as calf-feeding demonstrators. These club members have been furnished with a feeding record blank, and are keeping detailed records of all feed fed to calves, of gain and cost of gain in each case. Following is the record of cost of growing a pure-bred calf in Mercer County. The calf was fed corn-meal, skim milk, ground oats and calf-meal with roughage and pasture. The skim milk was elimi-

PLATE 1

FIG. 1. Sussex County Association members voted to make the county-wide tour an annual affair.

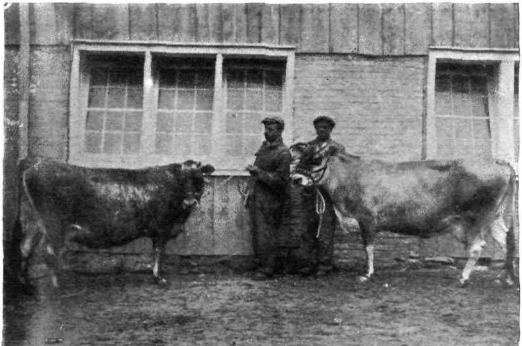

FIG. 2. Dam and daughter on the farm of Chas. Hires, Salem, New Jersey, a member of the Salem County Cow-Testing Association. Cow 13 at the left is the dam of Cow 10 at the right. The best record of No. 13 is 8,145 pounds of milk and 395 pounds of fat. The record of No. 10 at four years, 9,155 pounds of milk and 501 pounds of fat.

PLATE 2.

FIG. 1. WHAT A GOOD SIRE WILL DO

The cow at the left is a foundation cow in the State Hospital Herd at Trenton. Her best production has been 11,713 pounds of milk. Her first daughter, the cow at the right, has produced 14,008 pounds of milk in one year. She was sired by a pure-bred bull that proved to be the right kind. Increased production comes through the use of a tried herd sire.

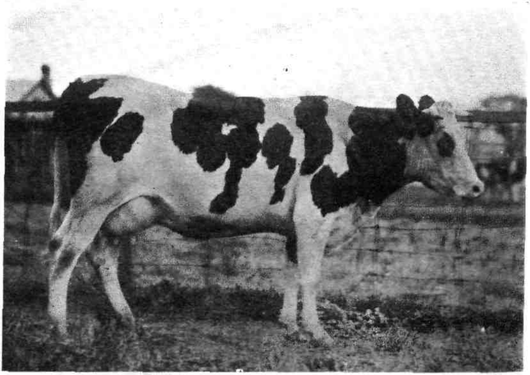

FIG. 2. AND WHAT A POOR SIRE WILL DO

Another daughter of the foundation cow from another bull. This cow produced a little over 6,000 pounds of milk as a 3-year-old. Her sire proved to be the wrong kind.

PLATE 3

FIG. 1. Boys of a Mercer County Calf Club studying important points i judging. Each of them has a pure-bred of his own. (From N. J. Agr. Col. Ex Bul. 23.)

FIG. 2. Four-months-old calves being raised on "The Home-Mixed Cal Meal," at Fairfield Dairy, Caldwell, N. J.

First Month—	
Weight at the beginning of first month	115 pounds
Weight at the end of first month	127 pounds
Pounds gain	22 pounds
Cost per pound	18c.
Total cost	$4.16
Second Month—	
Number of pounds gain	19
Cost per pound of gain	16c.
Cost of feed per month	$2.98
Third Month—	
Number of pounds gained	46
Cost per pound of gain	5c.
Cost of feed for month	$2.34
Fourth Month—	
Number of pounds gained	39
Cost per pound of gain	9c.
Total cost of feed per month	$3.61
Fifth Month—	
Number of pounds gained	39
Cost per pound of gain	9c.
Total cost of feed per month	$3.37
Sixth Month—	
Number of pounds gained	21
Cost per pound of gain	12c.
Total cost of feed per month	$5.49
Total cost of feed for 6 months	$22.05
Total gain	186 pounds
Total weight of calf	301 pounds
Average cost per pound of gain	11 3-4c. per pound

Feeding Demonstrations

The project on feeding demonstrations has been revised, and will be made a part of the county outline of dairy extension work this year. The project as now outlined will be carried on in the cow-testing association, the chief responsibility of the demonstration being placed on the cow tester. The plan of the demonstration is that the cow tester, when changing a ration for a dairyman, will notify the county agent of the change at least on one or two farms in the community. He will then compare the production of the herd, or a certain number of cows in the herd, as to the production of milk and the cost of the feed for 15 days before the change in the ration, and for 15 days after a new ration has been fed, allowing 15 days' interval for the herd to become accustomed to the new feed. The demonstrations will be carried on as follows:

Sussex County	6
Salem County	4
Cumberland County	2
Somerset County	3
Hunterdon County	4
Burlington County	2
Morris County	2
Sussex County	2

Following are the results of two such demonstrations in Sussex County:

Month	No. of Cows	Pounds of Milk	Cost of Roughage	Cost of Grain	Pounds of Grain	Ration
July	17	17019	$70	$84.60	2820	Silage—pasture 100 corn and cob 100 gluten 100 oats
August	16	14260	40	156.40	4887	Pasture 100 mixed feed 100 gluten
September ..	17	15990	50	102.00	3045	Pasture—green corn 100 brewers' grains 100 gluten 100 corn and cob

These records show that in August mixed feed was fed without succulence except pasture.

Month	No. of Cows	Pounds of Milk	Cost of Roughage	Cost of Grain	Pounds of Grain	Ration
October ...	12	5518	$42.00	$59.00	1966	Green fodder Pasture 100 brewers' grains 200 bran 100 hominy
November ..	10	5649	19.80	59.56	1805	Corn stalks and hay 200 hominy 100 brewers' grains 100 middlings 100 gluten 200 bran

This illustrates the value of a balanced ration fed according to production.

Miscellaneous Work

Aside from the regular special dairy project, considerable work has ›en carried on through personal visits, correspondence and farmers' eetings. The inquiries in regard to feeding have been answered al- ost wholly through the dairy extension force, and duriug the past :ar about 150 rations have been balanced as a result of inquiries to ıe department.

During the winter of 1919-20 some institute work was carried on by .e dairy specialist, and an approximate total of 50 meetings have been ldressed during the past year. One circular on judging has been pre- ıred for junior dairy extension work. Three circulars on feeding, ›w-testing association and bull association work were prepared for ıe exhibit at Trenton during Agricultural Week. Circulars on fitting ıttle for show and calf feeding, as well as directions and suggestions ›r carrying out calf-club activities have been prepared.

Dairy extension work for the coming year appears to show a greater ıprovement. The Sussex County dairymen are anxious to organize *Holstein-Friesian association. The Guernsey Breeders' Association* anticipating the organization of local Guernsey breeders' clubs along ıe lines of the organization carried out by the Holstein men this past :ar. Some organization work will be carried out toward organizing mi-official associations in counties where there are cow-testing asso- ations or Holstein-Friesian clubs. The semi-official association will ›nsist of about 10 members who will carry on 2-day tests under the ıpervision of the dairy department and for the national breed asso- ations.

There will, no donbt, be groups of dairymen in Mercer, Burlington ıd Salem counties who will bring in carloads of pure-bred heifers. his movement is already under way, and its realization will come this .ll or winter.

REPORT OF THE SPECIALIST IN FRUIT GROWING

A. Freeman Mason

In outlining the report for the year ending June 30, it is difficult to show the work in such a light as to bring out the results in the best fashion. It is the middle of the growing season, and although the preparatory work has been done on all the demonstrations, the results are not apparent nor can they be measured until the end of the season. Therefore, the preceding year's results may be given along with the preparatory work for the coming year.

During the past year a comprehensive outline has been drawn up covering extension work in fruit growing which will fit in with that of Prof. A. J. Farley's project covering the development of the fruit industry in the state of New Jersey, which he hopes to correlate also with the project of the State Bureau of Markets, of which A. L. Clark is chief. In outlining the project in this way, the experimental, the extension and the marketing phases advance hand in hand.

In drawing up the project for extension work in fruit growing, the state was divided roughly into three parts. The first part includes the districts where fruit growing is the major industry, and contains such counties as Burlington, Camden, Gloucester, Cumberland, Monmouth and Atlantic. The second group, including the districts in which fruit growing is a minor industry, contains such counties as Warren, Sussex, Hunterdon, Morris, Passaic, Essex, Bergen, Middlesex and Cape May. The third group in which fruit growing is of little or no importance, includes such counties as Somerset, Salem, Ocean, Union and Hudson. The type of extension work carried on in each of these groups is designed to meet the special needs of the group, and a set of projects covering the phases of the industry was drawn up to fit each. These were submitted to and approved by Professor Farley and Professor Blake, and were sent out to the counties.

The work was strengthened by the addition of Joseph French, as assistant specialist, who was added to the force on March 15, and who has since taken charge of the demonstration work in the northern part of the state. Reports from the county agents and growers indicate that Mr. French has more than made good, and a careful inspection of the demonstration orchards indicates that he has grasped the practical side as well as the scientific side of the work. The specialist in fruit growing has confined his efforts to the southern and central counties, with an occasional trip into the northern end to observe conditions there.

Nine projects were submitted to the county agents covering the important phases of demonstration work. These are as follows:

1. Apple-pruning demonstration.
2. Peach-pruning demonstration.
3. Spraying demonstration.
4. Fertilizer demonstration.
5. Cover-crop demonstration.
6. Peach-dusting demonstration.
7. Demonstration orchard.
8. Grape-pruning demonstration.
9. Orchard-management demonstration.

The spraying demonstration, peach-pruning demonstration, and demonstration orchard were the most popular. The first two of these were used in the southern end of the state altogether, while the latter was used entirely in the northern counties. There are 6 spraying demonstrations covering 744 trees, 6 peach-pruning demonstrations covering 661 trees, and 11 demonstration orchards containing 553 trees. These three projects have given us by far the most striking results of any nndertaken during the past year. A detailed discussion of each project follows:

Project 1, Apple-Pruning Demonstration

Four demonstrators were selected as follows:

Henry H. Albertson, Burlington, Burlington County..	100 trees.
Howard DeCou, Haddonfield, Camden County	150 trees.
George Martin, Tinton Falls, Monmouth County	22 trees.
Wm. Ackerson, Hazlet, Monmouth County	20 trees.

The first two of these demonstrations were started in March, 1919. A comparison of no pruning, pruning without heading back, and pruning and heading back was made on trees just coming into full bearing. These demonstrations are planned to cover a 5-year period, because results can scarcely be shown in training a tree in less time than that. However, the fall of 1919 brought out very clearly the desirability of having the tree open, when after a very serious scab season, Howard DeCou found that there was very little scab on the pruned trees which can be sprayed easily, while on the unpruned trees, which were thick and bushy, scab injured a considerable amount of the fruit. Good results also were secured at Henry Albertson's. The work was started this spring at George Martin's and Wm. Ackerson's, and inasmuch as the trees are approximately 40 years old in both places, it is expected that results will be seen this fall in the fruit.

Project 2, Peach-Pruning Demonstration

The peach-pruning demonstration has aroused considerable interest in Burlington and Camden counties. In these sections it is customary to allow the peach trees to grow with little pruning for eight of ten years, after which the trees are uprooted and burned, and a new or-

chard planted out. The specialist is endeavoring to demonstrate that the peach tree will last for 20 or 25 years if properly pruned, and the demonstration is designed to bring back or renovate these old, unfruitful orchards. Demonstrators were selected as follows:

Henry H. Albertson, Burlington, Burlington County..	247 trees.
A. J. Roberts. Moorestown, Burlington County	60 trees.
Hudson Haines. Rancocas, Burlington County	44 trees.
Chas. Leonard. Thorofare. Gloucester County	200 trees.
Julius Smith. Haddonfield, Camden County	48 trees.
Larsen Horner, Delair; Camden County	32 trees.
William Buzby, Rancocas, Burlington County	40 trees.

The work at Messrs. Albertson's, Roberts', Haines' and Horner's was started in April, 1919, with a comparison of five methods of demonstration, the short dehorning, high dehorning, heavy cutting-back and removal of one side of the tree at a time, and the dehorning of occasional branches each year. The high dehorning and heavy cutting-back gave by far the best results in every case, it being the specialist's opinion that the heavy cutting-back is the more practical and desirable, because no crop is lost during the operation, although the renovation takes a relatively longer time than the other methods.

At Mr. Albertson's 5 meetings have been held, each one being very well attended, and at which many of the leading fruit growers in New Jersey were present. Mr. Albertson has heavily cut back his entire orchard of approximately 100 acres of peaches as advised by the specialist. The demonstration block contained only the Smock variety, that variety being severely injured by the freeze of April 28, which caused the loss of the 1919 crop. However, the 1920 crop is coming along very satisfactorily, and some interesting results will be seen before the end of this season.

At A. J. Roberts' the best results of all the demonstrations were obtained in the matter of growth, even the short dehorned trees throwing out a full top, surprising the fruit growers in the neighborhood. Trees under all treatments set a heavy crop of fruit buds, but the trees which were short-dehorned threw the crop shortly after blooming, on account of the very rapid growth which took place. However, the trees under the high dehorning and heavy cutting-back have set fair crops and are holding them. In the fall of 1919, the trees which were heavily cut back had unpruned trees adjoining them as checks, and Mr. Roberts reports that there were far less peaches in number, but just as many in baskets on the heavily cut-back trees as on the checks, and that the pruned trees brought in considerably more money than the check trees because of the larger size of the fruit.

At Hudson Haines' the trees made a very satisfactory growth under all treatments, and set a very satisfactory crop of fruit, Mr. Haines going over half of his orchard and carrying out the heavy cutting-back method on his trees.

At Larsen Horner's only the heavy cutting-back method was demonstrated on a small block, and with such results that Mr. Horner treated his entire orchard in the same manner during the past winter.

At William Buzby's and Mr. Reid's the pruning demonstration was on young trees which had just been set out, a comparison of thinning out and heading back and no pruning being made.

The pruning on all the blocks under this project has been done by the specialist and county agent, and is developing satisfactorily in each case.

Project 3, Apple-Spraying Demonstration

The following demonstrators were selected for this project:

Lester Collins, Maple Shade, Camden County	330 trees.
S. H. Stanger's Sons, Glassboro, Gloucester County ..	128 trees.
Henry Albertson, Burlington, Burlington County ...	100 trees.
Henry Ackerson, Hazlet, Monmouth County	63 trees.
Edward Schimp, Hancock's Bridge, Salem County	72 trees.
Raymond Griggs, Cranbury, Middlesex County	51 trees.

The two most important demonstrations were under this project, being staged at the orchard of Lester Collins, Maple Shade, and S. H. Stanger's Sons, Glassboro.

The fruit growers of South Jersey have had considerable difficulty in controlling the codling moth, because of the fact that the emergence of this insect is so continuous that unless a thorough coating is maintained from the middle of May until the first of July, a very serious infestation is likely to take place. Mr. Stanger has been spraying six and seven times each season, while Mr. Collins has been spraying four or five times, but each of these growers had as much as a 40 and 50 per cent infestation of worms at picking time. Professor Farley and Dr. Headlee aver that this is due to lack of thoroughness of application, and the demonstrations were undertaken to back up their statements.

Up to the present time the Experiment Station schedule, consisting of six sprays, has been applied by the specialist to these orchards as well as to the others under this project, and a complete control has been secured. However, as the codling moth emergence continues for a considerable period yet, there may be later infestation. Conditions are being watched by Dr. Headlee, who will advise as to further applications, and if necessary the specialist will put on another spray.

The spraying work has attracted widespread interest in the counties, but the practical growers object to the Experiment Station methods, stating that they are entirely impractical both as to the number of sprays necessary and as to the laborious method of application. They claim that it would be impossible to find help who would be willing to work hard enough to put this spray on right, even if the method were not so expensive. The Experiment Station insists that unless the grower increases his mechanical equipment and labor force, or cuts down his acreage until he can carry out the Experiment Station recommendations, he will have a serious infestation of insect pests, and it is believed that the results which will be seen on the demonstration blocks at the end of the season will verify the station's contention.

Project 4, Fertilizer Demonstration

The fertilizer demonstration in the season of 1919 was carried ou in the orchards of the following:

Kenneth Adamson, Newton, Sussex County	42 trees.
Gruver Bros.. Fredon. Sussex County	36 trees.
William Pollard. Houses Corners, Sussex County ...	....
W. H. Skellinger, Plumsock, Sussex County	....
George Martin, Tinton Falls, Monmouth County	200 trees.

The results in the Sussex County orchards are discussed in th report of the assistant specialist.

At George Martin's manure was compared with nitrate and aci phosphate and no fertilizer. The application was made in April, an the results will not be apparent until the end of this season.

Project 5, Cover-Crop Demonstration

The cover-crop demonstration was not carried out in any specia place except in connection with the demonstration orchards, in som of which cover crops were planted as part of the orchard-managemen project. However, the ground has been prepared at Edward Schimp's Hancock's Bridge, Salem County, in an orchard of 600 trees, and vetcl and alsike will be planted in July. Mr. Cox, the agronomy specialist is cooperating in this demonstration.

Project 6, Peach-Dusting Demonstration

Three demonstrators have been selected in the Vineland district t carry out this project:

Walter Ellis, Vineland, Cumberland County	132 trees.
R. C. Mays, Vineland, Cumberland County	279 trees.
B. Gillette, Vineland, Cumberland County	180 trees.

The peach growers in the Vineland district have not taken up dust ing, although this method of insect and disease control has proven sat *isfactory, and has been recommended by the Station for several years* The specialist and the county agent have divided each block into thre parts, one part being dusted, the second being a check, and the thirc being a sprayed block, the idea being to compare the dusting and th spraying methods. Control has been obtained in both blocks, the ex pense in each being approximately the same. However, the labor ex pense saved in dusting is more than made up by the cost of th material, the only advantage in dusting being in the saving of labo in a section where labor is very scarce. Full results will be unobtain able until the end of this season.

Project 7, Demonstration—Orchard Project

In the spring of 1919, the demonstration orchard was the most im portant project, and gave the best results of any undertaking. Elevei

PLATE 1

RESULTS OF DEMONSTRATION AT CHARLES ROY'S FARM, FREDON, SUSSEX COUNTY

PLATE 2

ESULTS OF DEMONSTRATION AT JAMES BLACK'S FARM, HAINESVILLE, SUSSEX COUNTY

orchards were selected by the county agents for this work on the farms of the following:

James Black, Hainesville, Sussex County	72 trees.
Charles Roy, Fredon, Sussex County	36 trees.
Merritt Jones, Sussex, Sussex County	30 trees.
A. P. Messler (Pollard Farm), Houses Corner, Sussex County	....
Milton Gibbs, Mt. Hermon, Warren County	91 trees.
Charles Gibbs, Hope, Warren County	125 trees.
Henry Ackerson, Hazlet, Monmouth County	135 trees.
Samuel Buser, North Haledon, Passaic County	23 trees.

Four more demonstration orchards were carried on by the county agents, three in Bergen County, and one in Somerset County, but the results were not obtained in these orchards because the county agents did not have the time to devote to the work. The orchard situation in the northern end of the state makes the demonstration orchard project fit in very well with the county agent's work. Fruit growing is of minor importance in that section, and the growers have never learned to spray, prune or fertilize their trees. The county agent and specialist carried out the entire program in each demonstration orchard, putting on all the sprays and all the fertilizers and directing the harvesting and marketing of the crop. Pruning was impossible, because the orchards were not selected until blossom time. A few of the results taken from the December report are noted here.

Senator Henry Ackerson, of Keyport, has a Ben Davis orchard at Hazlet. This orchard had never been profitable. At the owner's request, the extension service made the orchard a demonstration orchard. The fertilization and cultivation were approximately those recommended by the Experiment Station. But little pruning was done on account of the lateness of the season. Six summer sprays were applied to a demonstration block of 60 trees, one spray of Pyrox being applied by the grower to the 200 trees west of the demonstration block, and two sprays of Pyrox to 125 trees east of the demonstration block. A field meeting was held in the orchard to witness the results, which follow:

		Per cent of crop		*Price*
SIX SPRAYS—	*5 trees*			
A Grade	22²/₃ bbls.	80.0	@ $5.00	$113.33
B Grade	4²/₃ bbls.	16.5	@ $3.00	14.00
Culls	1 bbl.	3.5	@ $1.50	1.50
	28¹/₃ bbls.	100.0 per cent crop		$128.83
TWO SPRAYS—	*5 trees*			
A Grade	1 bbl.	6.0		5.00
B Grade	11²/₃ bbls.	70.0		35.00
Culls	4 bbls.	24.0		6.00
	16²/₃ bbls.	58.7 per cent crop		$46.00
ONE SPRAY—	*5 trees*			
A Grade	¹/₃ bbl.	3.2		1.67
B Grade	7 bbls.	67.8		21.00
Culls	3 bbls.	29.0		4.50
	10¹/₃ bbls.	36.4 per cent crop		$27.17

Senator Ackerson, owner, and Mr. Voorhees, manager, state that they lost $2,000 net by not carrying out the Experiment Station schedule in the rest of the block. But by far the most important result of the demonstration was the cooperative purchase of 17 Bean Giant triplex power sprayers by Mr. Ackerson and his immediate neighbors.

James Black, Hainesville, Sussex County, has an orchard of 200 trees which had never been pruned or sprayed; 125 of them were pruned and sprayed on the Experiment Station recommendations. On September 26 a field meeting was held on Mr. Black's farm to observe the results. The following data and the photograph (plate 1) tell the tale:

	Average Per Tree		
	Yield	Per cent of crop	Value
FOUR SPRAYS—	bbls.		
A Grade	2.1	48	
B Grade	2.3	50	$22.33
Culls	0.1	2	
UNSPRAYED—			
A Grade	0.12	3	
B Grade	2.5	51	$3.25
Culls	2.3	46	

Mr. Black stated, on December 2, that he had sold his largest crop—*over 200 barrels—for over $1,000 net, and he is planting 4 acres of new* orchard, buying a good power spraying outfit, and is a leader in the movement for a pruning and spraying association in this community.

Charles Roy has an orchard of about 50 trees. A sprayer or a pruning saw had never been in the orchard. No pruning was done in the demonstration because of the lateness of the season when the orchard was taken. The Experiment Station schedule was carried out in spraying 36 of these trees. On September 25 a meeting was held to consider results, which are recorded in the following data and plate 2:

	Average Per Tree			
	Yield	Per cent of Crop	Value	
FOUR SPRAYS—	bbls.			
A Grade	5.3	65.0	$37.10	
B Grade	2.2	27.0	11.00	
Culls	0.6	8.0	1.50	
				$49.60
TWO SPRAYS—				
A Grade	3.2	42.5	$22.40	
B Grade	2.8	38.5	14.00	
Culls	1.4	19.0	3.50	
				$39.90
UNSPRAYED—				
A Grade	0.3	7.0	$2.10	
B Grade	1.9	49.0	9.50	
Culls	1.8	44.0	4.50	
				$16.10

On December 1 Mr. Roy submitted the following statement of expenses and returns:

90 barrels of apples sold net	$468.62		
1500 pounds cider apples net	15.00		
		$483.62	
Cost of barrels	$50.32		
Cost of spray materials	12.30		
Spraying labor: 2 men 10 hrs. apiece @ 35c.	7.00		
team 10 hrs.	3.50		
		$83.12	
Net proceeds, 36 trees		$400.50	

The harvesting expense can only be approximated because of the fact that it was done at odd times and no accurate records were kept by Mr. Roy. It approximates 40 per cent a barrel, or $36.

Milton Gibbs has 91 trees at Mt. Hermon, Warren County, which were strangers to pruning shears and summer sprays. The crop had previously brought anything from $50 to $300. These trees were sprayed according to the Experiment Station schedule. Notwithstanding the fact that the bloom was so light that Mr. Gibbs felt disinclined to go ahead with the schedules, on December 1 he had already sold $1,150 worth of apples, and had considerable fruit left in his cellar for later sale. He expects to improve and enlarge his plant. After all his crop was sold his net proceeds, after taking out all expenses, were $1,334.90 from 91 trees. Nine Hardie power sprayers were sold in Warren County as a result of this demonstration.

The report of Mr. French gives the detailed work in the demonstration orchards this season.

Project 8, Grape-Pruning Demonstration

The demonstrators on this project are as follows:

John Repp, Glassboro, Gloucester County	200 vines
Larsen Horner, Delair, Camden County	150 "
D. H. Tice, Woodcliff Lake, Bergen County	50 "

The *pruning demonstration* was started at John Repp's vineyard before the specialist assumed the position here in 1919, the pruning being done by Mr. McIntyre and Professor Blake on a 4-row block. Records were kept by Mr. Repp at picking time. He reports there was no particular difference in the yield under either system. This report is entirely satisfactory, due to the fact that it was estimated it would take at least two or three years to get results on the Kniffin system recommended by the Experiment Station, because of the difficulty in changing over from the one-wire brushy system practiced by Mr. Repp.

The demonstrations at Larsen Horner's and D. H. Tice's were undertaken this spring, a change being made from the one-wire to the two-wire system. Concord is the main variety grown in New Jersey.

Full results will be obtained during the present season at Mr. Repp's, and during tbe next year on the other two blocks.

Project 9, Orchard-Management Demonstration

In sections where the farm orchards are numerous, but in which the farming systems do not permit the owners to spend the necessary time in the early spring spraying their trees, there is a great opportunity for the farmers to club together and hire a man and outfit to spray their orchards. To demonstrate this, the orchard management project was written up, and the section about Sussex was selected for the demonstration. Eight growers owning approximately 1,500 trees were selected; one grower, W. W. Titsworth, with 700 trees, being very little in need of assistance, but included in the number to lend support to the group.

T. M. Morgan, who had taken two short courses at the college, and who had worked for one year with the horticultural department at the College Farm, was put in charge of the pruning, spraying, fertilization and harvesting of the crop for the association. It was understood that the growers would club together to buy power sprayers, fertilizers and spray materials. However, the spray machinery situation was hampered because of the tie-up in transportation facilities and to the unwillingness of some of the growers to spend a large sum late in the season for a spray outfit when there was doubt about getting it over the railroads. The spray materials, although shipped in plenty of time, were held up and did not arrive in time for the dormant spray. Neitber of these two difficulties have seriously interfered with the progress of

the demonstration, inasmuch as scale is not prevalent in Sussex County, and the Station was able to furnish a light power sprayer for the use of the association. However, a great many points have come up during the three months the association has been in existence which will strengthen the project if carried out during another season. For instance, some of the growers instead of mowing the grass, and using it as a mulch under the trees, insist on carrying it out of the orchard as hay this season. Two of the growers refuse to allow the manager to spray the orchards before cutting the grass, fearing it would poison the stock, the two orchards getting only two sprays during the season. Some of the growers did not buy adequate spray outfits. This project will be re-written before any additional associations are attempted, and the purchase of fully adequate spray outfits and the adherence to a definitely laid-out system of orchard management will be required. The set of fruit is good on all of the orchards, and the crops are clean, indicating that the association should have a successful year. Results cannot be given until the end of the season.

In addition to the work on the fruit specialist's projects, a large number of practicums and lectures have been given in different sections of the state. The State Department of Agriculture was assisted during the institute season. Judging was done at state and county horticultural shows, and farm visits were made in every county of the state. Circular letters were sent out during the spraying season to every county agent, calling attention to the times of application and materials. Stories were written for the press and the correspondence routine taken care of.

ANNUAL REPORT OF ASSISTANT SPECIALIST IN FRUIT GROWING

JOSEPH R. FRENCH

The writer took up his duties as assistant extension specialist in fruit growing on March 15, 1920. His work has been in Passaic, Bergen, Essex, Morris, Warren and Sussex counties.

Pruning practicums were held in March in Warren and Sussex counties, but because of the poor conditions of the roads, the attendance was generally small. Six practicums were held in Warren County and 7 practicums in Sussex County.

Beginning the first week in April, the demonstration-orchard project was taken over and the application of the dormant spray was made. There are 11 orchards included in this project on the farms of the following men:

Bergen County:
- C. B. Herold, Glen Rock.

Passaic County:
- A. E. Anderson, Upper Preakness.
- Samuel Buser, North Haledon.

Essex County:
- W. L. Smith, Chatham.

Morris County:
- Eugene Metz, Florham Park.

Warren County:
- Depue Roseberry, Belvidere.
- Milton C. Gibbs, Mt. Hermon.
- Miss Olive Wildrick, Delaware.

Sussex County:
- William Farber, Vernon.
- James Black, Hainesville.
- Charles Roy, Fredon.

Stable manure has been used on the Anderson, Smith and James Black orchards at the rate of 200 pounds per tree.

Commercial fertilizer has been used on the orchards of C. B. Herold, Samuel Buser, Eugene Metz and William Farber, at the rate of 5 pounds of nitrate of soda, plus 10 pounds of acid phosphate per tree.

The orchards of Depue Roseberry, Milton Gibbs, Miss Olive Wildrick and Charles Roy have been fertilized by either sheep, hogs or cattle pasturing the orchards.

The orchards have all been pruned, and at such times as the writer could spare, he assisted the farmers with their pruning. Many of the trees are too old for profitable spraying and had to be cut back within bounds.

At this writing all of the demonstration orchards have received five sprays, namely, the dormant spray, the pink bud spray, the petal-fall spray, the 10-day spray, and the June 20-30 day spray as recommended by the Experiment Station. The orchards of Depue Roseberry, Milton Gibbs, Miss Olive Wildrick, James Black and Eugene Metz have been sprayed with their own power sprayers purchased after the results of last year's work became apparent. The other orchards have been

sprayed with a Friend pony spray outfit hauled to the various orchards in a Ford runabout. The demonstration orchard of George Pollard, at House's Corners, was dropped early in the spring, because the owner, who is a city man, changed managers this year, and the new manager, being surrounded with labor difficulties, could not give the necessary cooperation. William Farber's orchard at Vernon was selected to take the place of Mr. Pollard's orchard, as there is a considerable demand for a demonstration orchard in this community.

The county agent of Sussex County reports that there is a decided demand for demonstration orchards in the communities at Walpack Center and Andover, but on account of the amount of work on hand this spring, it is not deemed advisable to take on any new demonstrations.

Fertilizer demonstrations were held in the orchards of the following four Sussex County men last year:

1. Gruver Bros., Fredon.
2. Kenneth Adamson, Fredon.
3. W. K. Skellinger, Plumsock.
4. George Pollard, Houses Corners.

The same orchards were visited again this year with the idea of continuing the fertilizer work. Gruver Brothers were so highly pleased with the results they obtained that they had fertilized all of their trees with the exception of the 40 trees that were fertilized last year, and these were again fertilized for demonstration purposes. Unfertilized checks were left.

Kenneth Adamson was so well pleased with the results obtained last year that he went ahead and fertilized his whole orchard, leaving no unfertilized check rows. He reported that all the fertilized blocks last year yielded apples ¼-inch larger in diameter than the unfertilized rows. It was an outstanding fact that the unfertilized trees of last year had practically no set of fruit this year, while the fertilized trees were set heavily.

W. K. Skellinger reported that his orchard did not yield enough more from the fertilization to warrant continuing the work. His orchard was in a very high state of fertility, due to the pasturing of a large number of hogs in the orchard. He noted that a few sickly trees had shown added vigor from the fertilization.

George Pollard's orchard was discontinued for the same reasons as were given for the discontinuance of the spraying demonstration.

At the present time plans are being worked out for the harvesting of this fall's crop. The growers are being advised to purchase containers early so that there will be no shortage at picking time. While a large part of the fruit will be sold on the nearby local markets, some of the fruit from the demonstration orchards will no doubt find its way to the large markets, such as Philadelphia and New York.

Fruit growers will be encouraged in every way possible to exhibit their fruit at the state and county fairs. Mr. Honston, the connty agent for Warren County, is planning to exhibit some fruit in trays, arranged in the same way as in bushel boxes, but holding only one layer of fruit.

REPORT OF THE DEPARTMENT OF AGRONOMY AND FARM MANAGEMENT

Department of Agronomy and Farm Management

FRANK APP, PH.D., *Agronomist*

ALLEN G. WALLER, M.SC., *Specialist in Farm Management Research*

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Report of the Department of Agronomy and Farm Management

Frank App

The activities of the department of agronomy and farm management for the past year include the work on field crops, farm management and miscellaneous.

FIELD CROPS

Testing Strains of Alfalfa Seed from Different Sources

The alfalfa plots seeded in the fall of 1917 continue to show the same results as in preceding years. Kansas and Nebraska seed, apparently, are giving a crop as good as the samples from Montana, North and South Dakota; Grimm, Baltic or Liscomb, as far north as New Brunswick. This is the third year for these plots, one of which has been a very trying one, and the results should be highly indicative of the value of these different sources of seed. It appears that seed produced in the vicinity of Kansas is sufficiently hardy and will give the best yield when used in New Jersey through that portion of the state extending as far north as and including New Brunswick.

Method of Seeding Alfalfa

The method of starting the alfalfa crop is taking on a more practical phase, inasmuch as many of the growers are using a portion of alfalfa with their regular grass-seed mixture, and seed with winter grain or oats as a nurse crop. This method is highly successful when the soil is well limed and the seed inoculated. When this is not true the timothy and clover of the mixture will furnish a good hay crop, whereas when conditions are right for the alfalfa, it will make a luxuriant growth and crowd out the timothy and red clover.

Corn Failures on Alfalfa Sod

The results of the investigational work at Minch Brothers Farms, at Bridgeton, were not conclusive last year, inasmuch as the heavy storms blew down much of the corn and influenced the yields. Table 1 is a record of these results.

Table 1

Corn on Alfalfa Sod

Results of Agronomy Project 100, Minch Bros., Bridgeton

Plot	TREATMENT	Yield Per Plot	Yield Per Acre	
		lbs.	lbs.	bu.
1	Check—1000 lbs. Bone, plus 200 lbs. 4-10	181.5	3086	38.6
2	1000 lbs. Bone	196.5	3341	41.7
3	1000 lbs. Bone, plus 400 lbs. Muriate of Potash	198.0	3366	42.1
4	1000 lbs. Bone, plus 1000 lbs. Acid Phosphate	183.5	3120	39.0
5	1000 lbs. Bone, plus 400 lbs. Nitrate of Soda	214.0	3638	45.5
6	Check—1000 lbs. Bone, plus 200 lbs. 4-10	168.0	2856	35.7
7	1000 lbs. Bone, plus 200 lbs. 4-10, plus 2 tons Ground Limestone	168.0	2856	35.7
8	1000 lbs. Bone, plus 200 lbs. 4-10, plus 300 lbs. Sulfur	181.5	3086	38.6
9	1000 lbs. Bone, plus 200 lbs. 4-10, plus 10 tons Manure	181.5	3086	38.6
10	1000 lbs. Bone, plus 200 lbs. 4-10, plus 150 lbs. Muriate of Potash	235.0	3995	49.9
11	Check—1000 lbs. Bone, plus 200 lbs. 4-10	203.0	3451	43.1
12	1000 lbs. Bone, plus 200 lbs. 4-10, plus 45 lbs. Muriate of Potash	199.5	3383	42.3
13	1000 lbs. Bone, plus 200 lbs. 4-10, plus 400 lbs. Acid Phosphate	183.5	3120	39.0
14	1000 lbs. Bone, plus 200 lbs. 4-10, plus 160 lbs. Nitrate of Soda	266.5	3681	46.0
15	1000 lbs. Bone, plus 200 lbs. 4-10, plus 300 lbs. Muriate of Potash	232.5	3953	49.4
16	Check—1000 lbs. Bone, plus 200 lbs. 4-10	206.5	3511	43.9
17	1000 lbs. Bone, plus 200 lbs. 4-10, plus 400 lbs. Acid Phosphate	239.5	4072	50.9
18	1000 lbs. Bone, plus 200 lbs. 4-10, plus 400 lbs. Nitrate of Soda	176.0	2992	37.4
19	Check—1000 lbs. Bone, plus 200 lbs. 4-10	212.0	3604	45.0
20	Check—1000 lbs. Bone, plus 200 lbs. 4-10	210.0	3570	44.6

Average yields (bushels per acre):
Check plots, 43.8; potash, 42.8; acid phosphate, 42.3; nitrogen, 42.9; lime, 35.7; sulfur, 38.6; manure, 38.6.

Soil analysis—Surface soil from corn planted on alfalfa sod:
Nitrogen, 0.131 per cent; phosphoric acid, 0.193 per cent; potash, 1.495 per cent.

No. 2, Subsoil taken from 8 to 18 inches of the same:
Nitrogen, 0.051 per cent; phosphoric acid, 0.127 per cent; potash, 1.366 per cent.

No. 3. Soil taken from healthy spots in alfalfa field which was not plowed, but had the same treatment as that on which corn was planted, except it would remain in alfalfa for the fifth year:
Nitrogen, 0.113 per cent; phosphoric acid, 0.197 per cent, and potash, 1.320 per cent.

No. 4. Is a surface soil from poor areas in the alfalfa field where it was short, yellow and very unhealthy:
Nitrogen. 0.107 per cent; phosphoric acid, 0.155 per cent; potash, 2.267 per cent.

Table 2

Results of Agronomy Project 101, Farm of D. D. Solomon, Potatoes on Alfalfa Sod, Freehold

Plot	TREATMENT	Yield Per Plot	Yield Per Acre	
		lbs.	lbs.	lbs.
1	Check—104 lbs. 4-8-3	330	6600	40.0
2	104 lbs. 4-8-3, plus 400 lbs. stable manure	396	7930	48.0
3	104 lbs. 4-8-3, plus 100 lbs. Mag. gr. limestone	433½	8670	52.5
4	104 lbs. 4-8-3, plus 125 lbs. gr. oys. shell	557	11140	67.5
5	125 lbs. 4-8-3	638	12760	77.3
6	125 lbs. 4-8-3	585½	11710	70.9
7	Nothing	465	9300	56.4
8	Check—104 lbs. 4-8-3	475	9500	57.5
9	25 lbs. muriate of potash	578	11560	70.1
10	109 lbs. acid phosphate	612	12240	74.2
11	44 lbs. nitrate of soda	431	8620	52.2
12	67 lbs. 4-8-3, plus 13 lbs. sulfur, plus 16 lbs. muriate of potash	526½	10530	63.8
13	Check—104 lbs. 4-8-3	285	5700	34.6
14	96 lbs. 4-8-3, plus 20 lbs. sulfur	413	8260	50.1
15	105 lbs. 4-8-3, plus 10 lbs. sulfur	548	10960	66.4
16	64 lbs. 4-8-3, plus 26 lbs. Tunnel's potash	441½	8830	53.5
17	91 lbs. 4-8-3, plus 22 lbs. muriate of potash	495	9900	60.0
18	104 lbs. 4-8-3, plus 6 lbs. muriate of potash	315	6500	39.4
19	72 lbs. 4-8-3, plus 36 lbs. acid phosphate	385	7700	46.7
20	100 lbs. 4-8-3, plus 20 lbs. nitrate of soda	380	7600	46.1
21	Check—104 lbs. 4-8-3	495	9900	60.0
	Average			56.2

Average yields (bushels per acre):

Potatoes on Alfalfa Sod

The results of the work in Monmouth County from growing potatoes on alfalfa sod showed much variation. The yield was low, indicating that the crop was influenced by the preceding year's growth of alfalfa. Table 2 is a record of the results obtained, together with the treatment of the different plots. The potatoes indicate that a large application of phosphorous was the most efficient agent in maintaining the yield of potatoes after alfalfa. The work on potatoes on alfalfa sod is being continued again in cooperation with the Monmouth County Board of Agriculture and D. D. Solomon, of Freehold. At the present writing there are some very striking differences.

Table 3

Results of Test of Ensilage Corn Varieties, College Farm, 1919

Plot	VARIETIES	Actual Yield per 1/20 Acre	Corrected Yield per 1/20 Acre	Moisture	Dry Matter Per Acre	Rank
		lbs.	lbs.	per cent	tons	
1	Eureka (Turner's seed)	1705	1770	75.0	4.42	2
2	Blue Ridge (Turner)	1310	1300	78.8	2.75	16
3	Blue Ridge, Boone County White Cross (Turner)	1360	1410	74	3.68	13
4	Boone County White (Horner)	1660	1580	76.2	3.76	3
5	Johnson County White (Coombs)	1510	1530	62.6	5.57	8
6	Mammoth White Ensilage (Phila.)	1530	1480	53.6	6.86	7
7	Red Cob White Ensilage (Hoffman)	1260	1445	57.2	6.18	17
8	Lancaster County Sure Crop (Hoffman)	1220	1170	55.0	5.26	18
9	Reid's White Cap (Reid)	1330	1355	55.0	6.10	14
10	Peacock (Peacock Bros.)	1380	1415	63.4	5.15	12
11	Wood's Eureka (College Farm seed)	1650	1660			4
12	Schmitz White Cap	1325	1450	69.4	4.44	15
13	Long's Champion	1460	1460	77.6	3.28	11
14	Borden's R. Y. D.	1570	1560	62.8	5.80	6
15	Golden Beauty	1470	1590	75.2	3.94	9
16	Salem Red Cattle Corn	1590	1490	65.9	5.10	5
17	Cock's Prolific (Wyatt)	1950	1890	81.6	3.48	1
18	Blount's Prolific (Wood)	1465	1370	59.2	5.58	10
19	Pennsylvania Sweepstakes (Bell)	905	845	61.0	3.29	20
20	Pennsylvania White Cap (Bell)	890	890	54.6	4.04	22
21	McAlpin Dent Golden (Walker)	900	870	56.8	3.76	21
22	Leaming (Stillman)	1100	1000	43.8	5.62	19
	Remainder—Wood's Eureka			78.4		
	Average			62.8		

Results of Work on Ensilage Corn

The ensilage corn varieties on the College Farm were selected from prominent strains grown in the state, together with some southern varieties which are frequently purchased by dairymen for ensilage production. While one year's results are not sufficient to warrant conclusions, the indications point to the fact that many of these southern varieties which have a long season for maturity will not make the highest quantity of dry matter per acre, and naturally are not of the best quality. Inasmuch as a number of the strains which we obtained from Virginia and other southern states did not produce as much dry matter as those grown within the state, it appears that the best source of ensilage corn is that in the state itself. The dairymen should recognize the value of home-grown corn. This would not mean that they should grow their own ensilage seed in every case, but they should have some reliable source within the state from which they could obtain their seed from year to year. Some of the growers are able to furnish their own seed. This is done by putting part of their ensilage crop out early in the season on a highly manured and fertilized piece of ground. This will mature the crop sufficiently to furnish good seed. When such conditions can be had this is a very desirable method.

Potatoes

The major portion of the potato work of the department is under the direct supervision of Prof. George W. Musgrave, who is giving his time to this crop.

Home-Grown Potato Seed

New Jersey is coming to the front as a seed-producing section, particularly the southern counties, including Cumberland and Salem. Their product, up to the present time, has compared very favorably with that of other sources. It appears that with the proper development the state could furnish its own seed, and in this way save a large expense to the industry in going out of the state. Table 4 is a record of the comparison of different strains obtained from different sources in 1919.*

Size of Seed-Piece

The average grower uses a seed-piece of about ¾-ounce size. From the results of 1919, it appears that these were just a little small to obtain the highest yield. This is particularly important in a season which is unfavorable for starting the crop. On the other hand, the results did show that there is less seed needed when late-crop New Jersey or Virginia seed is used. It appears that 3 barrels of late-crop

* In cooperation with Monmouth County Board of Agriculture and Dr. Wm. H. Martin.

seed would be about equivalent to 5 barrels of New York or Maine seed. In other words, a ½-ounce late-crop seed-piece is about as serviceable as a ¾-ounce seed-piece of New York or Maine-grown stock. It is probable that the soil type and amount of fertilizer used would also make some difference in the amount of seed that should be used at the time of planting.

Table 4

Comparison of Potato Strains

Source	*Yield per Acre*
Cobblers:	bu.
New Jersey late crop	160.00
Maine	138.16
Virginia late-crop	131.11
New Jersey immature	97.55
New Jersey late-crop	149.5
Giants (Samuel Buffet, Freehold):	
Dutchess County, N. Y.	170.1
Arostook County, Maine	280.8
Washington County, N. Y.	239.5
Genessee County, N. Y.	211.6
Late-Crop, New Jersey	220.9
Home-grown, Tennent, N. J.	211.6
Giants (Gilbert Sammis, Freehold):	
Vandeveer, N. Y.	304.0
Washington County, No. 2, N. Y.	303.4
Vermont	282.8
Late-Crop, New Jersey	302.3
Immature, New Jersey	268.7
Mature, New Jersey	179.3
Arostook Prize, No. 4	332.3
Arostook Prize, No. 1	339.7
Silver Fox, Maine	304.7
Howard Jones, Vermont	276.3
Giants (J. S. Holmes):	
Washington County, N. Y.	279.5
Late-Crop, South Jersey	300.6
Arostook Prize, Maine, No. 2	353.6
Arostook Prize, Maine, No. 1	381.8
Washington County, N. Y. Seconds	270.0
Giants (E. D. Reed, Tennent):	
Wilson Giants	336.1
Arostook Prize	359.4
Arostook Prize	336.2
Arostook Prize	317.2
Arostook Prize	311.5
Reid's matured seed from Wilson Giants	363.0
Late-Crop, home-grown from Wilson Giants	314.0

Table 5

Effect of Size of Seed Piece on Yield of Potatoes, Farm of Everitt D. Matthews, Mount Holly

SIZE OF SEED PIECE	YIELD PER ACRE					
	Firsts	Seconds	Total of Firsts and Seconds	Culls	Total Yield	Net Yield Over Seed
Variety—Giants						
	bbl.	bbl.	bbl.	bbl.	bbl.	bbl.
½ oz.	48.00	8.96	56.96	4.32	61.28	58.28
1 oz.	51.66	8.77	60.43	4.80	65.23	59.23
1½ oz.	.....	....	.....	....	.....	.....
2 oz.	57.28	9.60	66.88	4.32	71.20	59.20
4 oz.	41.44	9.12	50.56	4.80	55.36	31.36
Green Mountains						
½ oz.	58.56	5.44	64.00	1.76	65.76	62.76
1 oz.	67.84	6.40	74.24	2.56	76.80	70.80
1½ oz.	69.76	7.04	76.80	3.23	80.03	71.03
Late-Crop Seed						
½ oz.	65.92	9.68	75.60	4.48	80.08	77.08
1 oz.	65.44	7.36	72.80	3.68	76.48	70.48
1½ oz.	66.40	9.92	76.32	6.24	82.56	73.56
Whole potatoes	70.40	11.20	81.60	5.60	87.20	69.20

Rows 33 inches apart, plants 12 inches apart in the row.

Varieties

A study of varieties is being conducted in North Jersey, and also is contemplated in South Jersey with the late crop. Inasmuch as the two parts of the state vary so widely, it is essential that we have investigations of the best source for these different sections. Table 6 is a list of varieties which are being tested in cooperation with the Essex County Board of Agriculture and Mr. Francisco, on the latter's farm in Essex County.

Table 6

Potato Variety Test, Farm of Herbert Francisco, Caldwell, Essex County

Plot Arrangement

Plot 1	Check.*	
Plot 2	Green Mountains	A. G. Smith, Williamstown, N. Y.
Plot 3	Green Mountains	Lyman Pierce, Marathon, N. Y.
Plot 4	Check.	
Plot 5	Green Mountains	Monmouth County Farmers' Exchange, Freehold.
Plot 6	Green Mountains	Mark Rupley, Moravia, N. Y.
Plot 7	Check.	
Plot 8	Cobblers	Minch Bros., Bridgeton (marble size, planted whole).
Plot 9	Cobblers	Eastern Shore Produce Exchange, Va.
Plot 10	Check.	
Plot 11	Rural New Yorkers	Edw. F. Dibble, Honeoye Falls, N. Y.
Plot 12	Russets	Edw. F. Dibble, Honeoye Falls, N. Y.
Plot 13	Check.	
Plot 14	Giants	George W. White, Washington County Seed Association, Cassayuna, N. Y.
Plot 15	Giants	Wm. McClay, Greenwich, N. Y.
Plot 16	Check.	
Plot 17	Giants	Monmouth County Farmers' Exchange, Freehold.
Plot 18	Norcross	F. G. Carter, Marathon, N. Y.
Plot 19	Check.	
Plot 20	Mill's Prize	Elmer Hults, Marathon, N. Y.
Plot 21	Check.	

* Check—Seed used by grower—Cobbler, Green Mountain and Rural New Yorker types.

Row 1 begins at the lower side of the field adjoining the fence and runs the full width of the field, 286 feet.

FARM MANAGEMENT

Investigational work in farm management has centered along lines of cost of producing farm products. A. G. Waller is employed jointly by the State Experiment Station and the United States Department of Agriculture at Washington in pursuing this work.

Cost of Producing Can-House Tomatoes

This project, which was started in 1918, is being continued until sufficient data have been accumulated to represent the growth of the crop under different seasons and different conditions which influence the cost so widely.

In 1918, the average tomato yield per acre was 6.2 tons of tomatoes harvested, whereas, in 1919, the acre yield for the five main counties producing tomatoes was 2.08 tons of tomatoes harvested. The season

for 1918 was exceptionally good, whereas that of 1919 was exceptionally unfavorable for the production of the crop. The main difference of cost between the two years is in harvesting the small and the large yields. Otherwise, costs are very similar, excepting in so far as the price of materials and labor have changed. These were somewhat higher in 1919 than in 1918.

Table 7

Expenses for the 1918 Tomato Crop

Items Per Acre	Burlington	Camden	Gloucester	Cumberl'd	Salem	Average
Seed	$4.67	$2.71	$1.63	$1.73	$1.61	$2.93
Plants	....	....	....	....	....	....
Cover Crop	1.41	1.10	1.14	0.45	0.19	1.02
Baskets	6.06	6.04	4.66	4.19	3.11	5.23
Fertilizer	14.71	15.63	15.80	15.00	11.12	14.80
Manure	10.52	15.60	13.88	16.44	23.19	14.50
Lime	0.08	0.16	0.24	0.58	0.13	0.21
Spray	1.49	0.77	1.44	0.14	0.09	0.96
Man labor	40.75	42.77	38.54	35.38	34.58	39.36
Horse labor	20.16	27.18	15.01	17.18	18.90	20.32
Machine labor	6.23	7.21	5.75	6.16	5.59	6.30
Truck labor	4.12	2.32	12.65	1.83	0.45	4.36
Tractor labor	....	0.30	....	....	0.56	0.12
Land rental	9.57	9.95	9.52	10.63	6.78	9.54
Interest	1.79	1.98	1.79	1.65	1.59	1.79
Supervision	12.15	13.36	12.14	11.42	10.79	12.13
Total cost	133.71	147.16	134.19	122.57	118.68	133.57
Ton cost	18.51	22.13	21.52	24.87	20.95	20.96
Acre yield	7.2	6.67	6.2	4.75	5.69	6.37

During 1918, 80 per cent of the entire crop was produced at $26 or less per ton; 92 per cent at $30 or less per ton, whereas, in 1919, the same proportions of the crop cost $70 and $100 per ton, respectively. It cannot be expected that a price would be set which would cover the cost for all the growers. Producers in most industries do not receive prices which allow all of those interested to make a profit or obtain the cost of production. The tomato canning industry was very much handicapped by the condition of the can-house market, which made the canners feel that they could not afford to offer a high contract price. The growers, on the other hand, did not feel that they could grow them for the price offered by the canners. The Government held large quantities of their pack which they purchased from the 1918 crop. The likelihood of this pack being thrown on the market led the canners to

Table 8

Materials Used Per Acre for the 1918 Tomato Crop

Items Per Acre	Burlington	Camden	Gloucester	Cumberl'd	Salem	Average
Plants (number)	1573.50	896.83	536.20	38.80	200.00	893
Seed (lbs.)	*0.07*	*0.12*	*0.14*	*0.216*	*0.164*	*2.176 oz*
Cover Crop (bu.)	0.77	0.58	0.51	0.09	0.06	29 lb
Baskets (number)	*42.77*	*42.15*	*31.64*	*30.24*	*21.60*	*37*
Fertilizer (tons)	0.43	0.42	0.39	0.40	0.33	801
Manure (tons)	5.31	7.4	7.75	9.40	11.80	7.23
Lime (tons)	0.15	0.002	0.0086	0.110	0.04	175 lbs
Man labor (hrs.)..........	157.32	169.10	126.50	117.80	115.50	142
Horse labor (hrs.)	105.36	120.10	81.70	94.80	93.20	100
Machine labor (hrs.)	105.36	120.10	81.70	94.80	93.20	100
Tractor labor (hrs.)	....	0.22	.....	.....	.....	0.08
Truck labor (hrs.)	3.15	1.35	8.70	1.48	0.44	2.93

Table 9

Materials and Labor Used in Tomato Production in New Jersey, 1919

Items Per Acre	Burlington	Camden	Gloucester	Salem	Cumberl'd	Average
Seed (lbs.)	*0.14*	*0.10*	*0.13*	*0.17*	*0.25*	*0.16*
Plants (number)	2258	882	1337	650	562	1320
Cover crop seed (bu.)	1.2	0.16	0.60	0.17	0.64	0.84
Baskets (number)	26.25	17.61	16.15	11.52	17.55	19.4
Fertilizer (lbs.)	910.70	894.62	942.70	697.15	1075.80	891.5
Manure (tons)	6.05	4.78	7.09	13.15	8.6	6.00
Lime (tons)	0.56	0.19	0.24	0.20	0.42	0.35
Spray materials (lbs.)	6.14	3.48	4.35	0.70	0.81	4.0
Operator's labor (hrs.)	26.60	30.47	26.10	24.80	35.93	28.3
Hired labor (hrs.)	78.31	73.17	74.33	49.69	46.52	73.9
Horse labor (hrs.)	74.58	88.95	61.78	67.72	64.52	74.0
Machine labor (hrs.)	74.58	88.95	61.78	67.72	64.52	74.0
Truck labor (hrs.)	3.26	1.61	3.26	0.37	0.38	2.2
Tractor labor (hrs.)	0.87	0.10	0.12	0.30	....	0.2
Land	673	502.50	361.80	227.50	201.50	....

Table 10

Cost of Tomato Production in New Jersey, 1919

Items Per Acre	Burlington	Camden	Gloucester	Salem	Cumberl'd	Average
Hot-bed materials	$0.92	$2.39	$0.79	$0.58	$0.47	$1.19
Seed	0.46	0.54	0.62	0.75	0.98	0.60
Plants	6.09	2.69	3.39	1.26	0.87	3.63
Cover-crop seed	2.20	2.12	1.40	0.37	0.39	1.68
Baskets	3.57	2.33	1.06	1.49	2.33	2.59
Fertilizer	19.65	19.47	26.40	13.97	18.48	20.08
Manure	13.97	12.20	14.78	23.01	17.45	15.07
Lime	1.07	3.61	0.82	0.54	0.96	1.60
Spray material	0.93	0.66	1.52	0.09	0.08	0.78
Operator's labor	11.45	13.19	11.60	12.11	14.14	12.28
Hired labor	23.95	22.27	23.05	15.22	13.81	21.31
Horse labor	18.30	18.80	14.67	12.49	10.92	16.38
Machine labor	5.21	6.23	4.32	4.74	4.52	5.18
Truck labor	4.82	2.12	4.90	0.56	0.57	3.22
Tractor labor	0.56	0.15	0.17	0.45	....	0.31
Land rental	9.04	12.69	10.33	8.06	10.42	10.24
Insurance	0.13	0.30	0.42	0.06	0.05	0.21
Use of auto	0.50	0.16	0.42	0.21	0.07	0.32
Interest on money	1.86	1.82	1.76	1.45	1.45	1.74
Total per acre	$124.74	$123.74	$123.38	$97.41	$98.18	$118.41
Total per ton	46.21	55.73	68.77	85.42	80.48	56.56
Acre Yield (tons)	2.7	2.22	1.79	1.14	1.22	2.08
Number of Farms, 1919	56	41	48	29	31	205
Total Acres, 1919	673	502.5	361.8	227.5	201.5	1966.3
Total Acres, 1918	*850*	*567*	*404.5*	*246*	*399.25*	*2468.75*
Number of Farms, 1918	70	40	47	33	50	240
Acre-Cost, 1918	$133.72	$147.16	$134.19	$118.69	$122.55	$133.57
Ton-Cost, *1918*	*$18.51*	*$22.13*	*$21.52*	*$20.85*	*$24.87*	*$20.96*
Acre Yield (tons)	7.2	6.67	6.2	4.75	5.69	6.37

feel that there would be a surplus of the canned product, which would not allow them to invest in a high-cost pack.

It is evident that a crop, such as the can-house tomato, needs a more stabilizing influence in order to encourage the grower and the canner to produce sufficient for consumption, and at the same time allow a profit for the producer and canner alike. Inasmuch as this crop is a

Table 11

Cost of Tomato Production by Groups

Cost Per Ton	Number of Farms	Acres	Tons	Per cent of Crop	Ton Cost	Acre Cost	Acre Yield
1919							tons
$40 or less	30	373.0	1380.60	0.34	$32.41	$119.98	3.70
$40.1 to $50	36	445.0	1109.66	0.60	46.44	115.80	2.49
$50.1 to $60	28	276.5	674.41	0.77	55.91	136.36	2.44
$60.1 to $70	20	168.0	316.88	0.84	65.62	123.78	1.89
$70.1 to $100	29	218.5	307.59	0.92	83.29	112.67	1.40
$100.1 to $130	21	174.8	173.64	0.96	109.81	109.08	0.99
$130.1 plus	41	310.5	153.70	1.00	213.11	105.49	0.49
Total or Average	205	1966.3	4116.48	....	$56.56	$118.41	2.09
1918							
$14 or less	12	111.5	1039.00	0.07	$11.89	$110.77	9.30
$14.1 to $18	50	564.0	4669.28	0.36	16.24	134.43	8.30
$18.1 to $22	63	653.0	4553.55	0.65	19.72	137.50	6.97
$22.1 to $26	43	426.5	2330.00	0.80	24.22	132.34	5.46
$26.1 to $30	40	380.25	1913.24	0.92	27.09	135.35	5.00
$30.1 to $40	21	261.5	1057.30	0.99	32.01	133.25	4.00
$40 plus	11	72.0	171.77	1.00	48.55	115.82	2.39
Total or Average	240	2468.75	15734.14	....	$20.96	$133.57	6.37

national one, of a large acreage, it is essential that the growers in the can-house states, as well as the canners, will need to have an understanding concerning the production of this crop, which will allow reasonable profit. The recent action of the tomato-producing states and the National Canners' Association, in cooperation with the Tomato Growers' Association, promises to bring a stabilizing influence to bear on this enterprise, so that its production will not be a hardship to those interested. This movement will be to the interest of everyone concerned, including producer, canner and consumer.

Cost of Producing Potatoes

This investigation includes work on two crops—the early market crop and the seed crop—so largely grown in Cumberland and Salem counties. Work on the commercial crop only will be reported at this time.

Table 12

Cost of Potato Production per Acre in New Jersey, 1919

ITEMS	Monmouth	Salem	Cumberland
1. Seed	$27.76	$17.55	$15.48
2. Cover crop (seed, bu.)	1.39	.....	0.43
3. Baskets, barrels and bags	1.01	1.75	2.41
4. Seed treatment	$0.57	.....	$1.46
5. Fertilizer	59.07	40.79	41.01
6. Lime	.....	1.03	0.36
7. Spray	4.11	3.61	4.76
8. Manure	0.34	20.00	28.12
9. Operator's labor	13.65	15.48	19.47
10. Hired labor	25.83	19.96	22.88
11. Horse labor	18.33	24.18	22.72
12. Machine labor	8.01	7.88	8.26
13. Tractor labor	0.83	.....	0.42
14. Truck labor	1.03	0.25	0.98
15. Land rental	19.18	9.95	9.35
16. Insurance	0.61	0.15	0.23
17. Interest	2.74	2.09	2.60
Total cost per acre	$185.90	$165.26	$179.61
Total cost per cwt.	$1.60	$2.07	$2.05
Total cost per basket	$0.53	$0.69	$0.68
Yield per acre, cwt.	115.96	80.01	87.64
Yield per acre, bas.	347.8	240.7	262.92
Yield per acre, bbls.	69.5	48.1	52.58

The acre cost varied from $185.90, in Monmouth County, to $165.26 in Salem, and $179.61 in Cumberland. The yield per acre varied from *69½ barrels in Monmouth, to 48.1 barrels in Salem, and 52.58 barrels* in Cumberland. This was at a cost of $2.65 per barrel for Monmouth, $3.45 for Salem, and $3.40 for Cumberland. The cost was relatively high, yet not more than one should expect for a crop which received such a high amount of fertilizer, manure and labor as the potato crop. The cost per unit of production, as represented by the barrel, basket or hundred weight, was not excessive. The work shows that New Jersey is unusually well adapted for the production of this crop, and will continue to develop and increase its acreage as its soils and markets will warrant.

Studies on the cost of producing other farm products mentioned in the introduction are under way, but are not far enough along to warrant any report at this date.

Table 13

Materials and Labor Used per Acre in Potato Production in New Jersey, 1919

ITEMS	Monmouth	Salem	Cumberland
1. Seed (baskets)	26.08	18.77	16.99
2. Cover crop (seed, bu.) ...	1.39	.....	0.43
3. Baskets and barrels	1.53 bbl.	16.3 bas.	15.74 bas.
4. Seed treatment	$0.57	.....	$1.46
5. Fertilizer (lbs.)	1,742.73	1,905.0	1,959.49
6. Lime (lbs.)	.....	561.0	220.23
7. Spray (lbs.)	10.92	.....	22.86
8. Manure (tons)	0.33	11.0	15.01
9. Operator's labor (hrs.) ..	25.42	34.7	42.32
10. Hired labor (hrs.)	73.00	63.8	71.85
11. Horse labor (hrs.)	98.23	113.0	117.87
12. Machine labor (hrs.) ...	98.23	113.0	117.87
13. Tractor labor (hrs.)	0.55	.....	0.21
14. Truck labor (hrs.)	.....	.....	0.61

Farm Cost Accounting

The operators of a number of selected farms in the southern part of the state are keeping records of all of their farming operations. Through their records it will be possible to obtain the actual cost of horse labor, tractor labor, truck labor, equipment and machine labor, as well as the actual cost of man labor on these farms. They will also show methods which may be used in reducing man-labor costs. This system of accounting will have an important bearing upon the organization of the farm, as it represents what in industrial circles would be called the work of efficiency engineers or the business end of operations.

Price Relationships

A study of price relationships is under way in connection with the work on the cost of production. Price relationships illustrate the relative price of farm products and industrial products from industrial centers. Farmers, in a general way, appreciate the cost of producing products. At the same time they have no actual data which they can use or present to the public to show when they are producing at a loss.

The public frequently objects to the high cost of a food product which is being produced below its cost of production, and continues to object because the farmer cannot present his true cost and show that he is carrying the enterprise at a loss. Such information is highly important to assist the farmer in marketing and encouraging consumption. When the consumer feels that he is paying too much, he not only objects to the price, but also decreases his consumption. Thus, he forces the price down still lower because of his belief that he is paying an excessive price to the producer. Whenever the manufacturer or the retailer of products other than food-stuffs sells his commodity to the public below the list price—which is a reduction not below the cost of production but rather below his customary selling price—he advertises the fact, giving the per cent of reduction, and in this way increases the consumption of his goods. The public purchases quite freely under these conditions. The consumption is increased, and frequently the retailer can make more money because of the increased business which he is handling under normal conditions. The same principle should be followed by the farmer in marketing his large crops.

On account of war conditions and the temporary influence of high prices, various commodities are produced in such amounts that the market will become temporarily flooded and the producer stands to lose because of this excessive production. Were he in a position to launch a campaign advertising the fact that a certain crop or livestock product is being sold so much below the ordinary cost of production, it is highly proper that he should thus endeavor to stabilize prices and not suffer serious losses as he has in the past. Such a campaign would be beneficial to both the producer and the consumer. The producer would receive more nearly his cost of production during years when there is drop in the market, and at the same time the consumer would be encouraged to purchase a larger quantity of the products. It is frequently realized that the small crops bring the farmer more money than the large ones. On the other hand, it is usually true that a succession of short crops will lower the prosperity of the nation, and in that way influence the state as well as the country. Thus, large crops may at times be a temporary hardship to the farmer, but small ones are a hardship to everyone. Large crops and ample production, properly regulated, would be a benefit to all.

A THREE-YEAR FARM MANAGEMENT SURVEY OF TRUCK FARMS IN GLOUCESTER COUNTY, NEW JERSEY

GEORGE A. BILLINGS AND LEON G. HOWELL

General Plan of Study

This is one of a series of publications on the management of farms in the most important trucking regions of the United States.[1] It is the result of a 3-year study, 1914 to 1916 inclusive, of the farm business in one of the most important and successful vegetable-growing regions along the Atlantic coast furnishing the markets of New York, Philadelphia, Boston and inland cities.

While the methods of farm practice adopted by the farmers in this region differ somewhat from the practice of truckers in other regions, it is the result of years of experience which has proven most profitable in the region. The results of this study will apply to the sandy soil areas of the Coastal Plain in Long Island, New Jersey, Delaware, Maryland and Virginia.

OBJECT OF STUDY

The object of this study was to obtain fundamental data on the general organization of the most successful farms and the methods of farm operation which would assist in planning truck farms in this region or which would be suggestive to those farmers who have not been successful. The scope of the study includes the following:

The distribution of capital invested and the crops grown; the farm income; the expenses of operating the farm business, and the influence of these factors on the profits of the farms in the area: the cropping systems and rotations best adapted to the farms in this area; the farm practices in the use of manures and fertilizers; the soil and crop management and the influence of these practices on economic production; the yearly variation in crop yields and the prices received from farm products and the influence of climate or market conditions on profits: the relation of such factors as size of farm, crop yields, market prices and efficiency of labor on the net profits of the farm in this area; the labor requirements and distribution, and the methods of handling labor; what the farm furnishes the family in the way of food, such as vegetables, milk, fruit, firewood, house rent, etc.

SUMMARY OF RESULTS

The average size of 125 farms studied for the 3-year period was 80.8 acres, of which 53.3 acres, or 66 per cent of the land, was in crops. Twenty-two per cent of the crop area was in hay and small grain, 18.6 per cent in field corn, 22.2 per cent in sweet potatoes, 16.8 per cent in early tomatoes, 5.1 per cent in early white potatoes and the balance in miscellaneous truck crops.

The yield of truck crops varied considerably during the 3-year period, being influenced by weather conditions. The variations in yield of the four leading truck crops were as follows: tomatoes, 254 baskets in 1915 to 397 baskets in 1916; sweet potatoes, 184 baskets in 1916 to 260 baskets in 1915; white potatoes, 163 baskets in 1914 to 188 baskets in 1916, and asparagus, 57 crates in 1914 to 65 crates in 1915.

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[1]The authors were connected with the Office of Farm Management of the United States Department of Agriculture when this study was made. Arrangements were made with the New Jersey Agricultural Experiment Station and the plan of study received their approval and cooperation.

The cropping system is usually arranged to give the most favorable conditions to the principal market crops, tomatoes and sweet potatoes, and furnish corn and hay for livestock. No definite rotation is generally followed but often there is a succession of crops as follows: corn, sweet potatoes, early potatoes, and clover-mixed hay.

There is an increased interest in the planting of cover crops, such as rye, cowpeas or soybeans, and crimson clover to be turned under for green manure. These crops are being grown with a view of replacing the city manure usually purchased, the cost of which has greatly increased in recent years.

The livestock industry is a secondary feature in this region. Cattle are kept merely to use up surplus roughage and supply the family with dairy products. Hogs are kept mostly to supply the family with meat. The poultry industry is on a more commercial scale, furnishing considerable income on some farms.

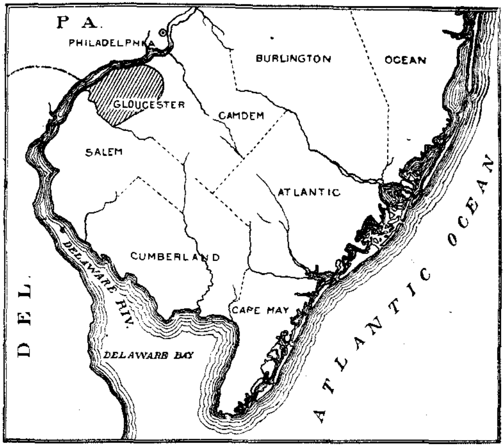

FIG. 1. MAP OF SOUTHERN PORTION OF NEW JERSEY, SHOWING AREA IN WHICH THE SURVEY WAS CONDUCTED.

The total annual farm receipts varied from $2,300 on small farms to over $4,000 on the largest farms. The crop receipts represented 86.3 per cent of the income and livestock receipts 10.6 per cent.

The largest item of expense was for labor, which was 35.1 per cent of the total expense. Eleven and one-tenth per cent was for manure. 13.7 per cent for fertilizers, 9 per cent for baskets and crates, and 9.1 per cent was for food.

The average real estate investment was $7,850, and operating capital $2,595, or a total investment of $10,445. The average estimated price of land, with buildings, in 1914 was $97 per acre.

The small farms do not seem to offer the opportunity for large net incomes compared with large farms. Farms with 75 or more acres of tillable land produced nearly three times the labor income from farms having 35 tillable acres or less.

The large farms use labor with greater efficiency. On small farms 12.1 acres of crops were handled per man and 10.5 acres per horse, while on the larger farms 20.9 and 14.3 acres were handled per man and horse, respectively.

On farms where the crop yields were 29 per cent above the average in the region, the average labor income was $1,655. When crop yields were 23 per cent below the average, the labor income was $528. This shows to what extent crop yields are a factor in farm profits.

The prices received for market crops is also an important factor in farm profits. Thirty-eight farms that sold crops at a price 19 per cent above the average for the 125 farms had a labor income $600 above the average for all farms.

The farm practice in the use of manures and fertilizers in this region is generally profitable, particularly with the intelligent use of commercial fertilizers. A study of the use of purchased city manure during the 3-year period seems to indicate that the prices paid for manure could not be increased and return a profit unless the prices received for crops were correspondingly increased or other factors adjusted.

The value of what the farm contributes toward the family living in fruit, vegetables, meat and dairy products amounted to $276 per family of an average of about five persons. This amount, together with the value of house rent and firewood cut from the farm, is an income in addition to the farm and labor income reported.

GENERAL DESCRIPTION OF THE AREA

Location

The region selected for study was the western part of Gloucester County, New Jersey, bordering the Delaware River. It comprises about six townships covering an area of approximately 100 square miles. The northern boundary is about 10 miles due south of Philadelphia, Pennsylvania, and the southern line which forms a part of the northern boundary of Salem County, is a little over 20 miles from this city. Woodbury is the county seat, but Swedesboro is the principal shipping point by rail to points north and west and by boat to Wilmington, Delaware, and Baltimore, Maryland. In the vicinity of Woodbury much of the farm produce is hauled directly to Philadelphia markets.

Topography

The region of Gloucester County is situated on a plain of low relief gently sloping toward the Delaware River from a ridge extending in a northeasterly direction from the vicinity of Delaware Bay near Bridgeton. In some places the land is nearly level or on a slope of not more than 5 feet to the mile and broken by low hills or marshes along the creeks unsuitable for tillage. Along the shore of the Delaware River is a strip of lowland or terrace of varying width which rises gently to an elevation of 40 to 50 feet above sea level. These lowlands are tide-water meadows, which in many places have been diked and which produce salt hay of a very good quality. Several creeks cross this area rom the southeast to northwest, Raccoon, Mantua and Woodbury creeks being mong the largest and navigable to small boats.

The tide rises in Raccoon creek through the area studied and the banks of he creek are bordered by tidal marshes, part of which is pastured or cut for ay. The general level of the surface of the plain lying northwest of the Voodbury-Salem pike in the vicinity of Swedesboro varies from 50 to 95 feet bove sea level and is gently undulating.

Nearer Woodbury, in the vicinity of Thorofare, is a low undulating plain ormed by the angle of the Delaware River and Woodbury creek. This terace gradually rises from tide-water, the highest elevation seldom being above 0 feet.

Soils

The soils of the Coastal Plain have their origin in deposits of glacial material from marine waters as off-shore sediments at a time when the land surface was much lower than at present. They consist of unconsolidated layers of clay, sands, gravel and marls. This material has been reworked, under the agencies of erosion and surface weathering assisted by the action of streams and waves, resulting in a variety of soil types.

The Coastal Plain in this region may be considered under three distinct divisions, a tide-marsh area connecting the beach with the mainland, a curved belt of land adjoining the tide-marsh area, which is preeminently a farming section, and a more or less forested area farther inland. This intermediate belt has been developed agriculturally in Gloucester County to a marked degree. The character of soil in this belt along the Delaware River is not as porous as along the Atlantic slope, particularly in Atlantic and Ocean counties, where in some places the soils are so sandy as to have but little agricultural value.

The texture of the sandy soils in Gloucester County varies from a fine to a coarse, loamy sand, the fine sand predominating. These soils are underlaid with a still more loamy and somewhat sticky sand containing in some places considerable clay. The sandy soils are distributed somewhat irregularly, being dominant in a narrow belt along the Delaware River. Farther inland and to the south and southeast in Salem County the soils consist of much heavier loams well adapted to growing white potatoes, grain and hay. On the more sandy soils sweet potatoes and early tomatoes predominate. Truck crops occupy about one-half of the total area.

Soil surveys[2] have been made in several areas of the Coastal Plain, particularly in the vicinity of Trenton, Salem, and small areas in the vicinity of Swedesboro and Thorofare. The sandy soils predominate and their character varies from a fine sandy to a coarse sandy or gravelly loam. A soil with a large amount of sand particles of medium size is considered a sandy loam. Graduations above or below this type of soil are designated as coarse or fine sandy loams. A soil with very little clay is not a loam but is generally called sand. The more sandy soils occur in larger areas in a belt along the Delaware River or along the larger creeks; the coarse sandy loams are further inland in scattered areas, interspersed with irregularly shaped areas of finer sandy loams, and the coarse gravelly, sandy soils are located in smaller scattered areas and occur on slopes or as small knobs or knolls. The drainage of the coarse sandy or gravelly soils is often excessive for good crop yields.

The classification of soil types as given by the United States Bureau of Soils[3] divides the soils of Gloucester County into four groups; the Sassafras series represented by six types; the Collington series by two types; the Colts Neck series by two types, and the Portsmouth series by one type of soil.

The Sassafras series of soils are the most prominent in the region. The Sassafras sandy loam occurs more particularly in irregular areas on both sides of the Woodbury-Swedesboro pike and this type represents one of the best trucking sections. The Sassafras coarse sandy loam occurs in larger areas northwest of this pike and produces good yields of a variety of truck crops by the use of manures or other organic matter. Approximately one-third of the total area in the vicinity of Swedesboro is of this type of soil. The Collington fine sandy loam is somewhat deeper than the Sassafras series of soils and is recognized by its dark brown color. It occurs in small areas as local accumulations of fine sand on some of the slopes and is well suited for growing early white potatoes and more general farm crops. The Portsmouth sandy loam occupies a more restricted area where drainage is poorly established. It is recognized by its dark mucky character and is better suited for the production of general farm crops, cabbage or small fruits.

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[2] U. S. Department of Agriculture publications; Soil Survey of the Trenton area; Soil Survey of the Salem area; Soils of Southern New Jersey and Their Uses, U. S. Dept. Agr. Bul. 677.

[3] U. S. Dept. Agr. Bul. 677 (Loc. Cit.).

In the southeastern part of the region studied, namely, in Harrison township, the soils are much heavier and well suited for such crops as white potatoes, asparagus, tomatoes, corn and hay. The surface is more rolling than on the more sandy types of soil; often broken by wooded streams and meadows which give conditions better adapted to raising livestock and to dairying. The heavier soil has intervening areas of lighter sandy soils which are usually devoted to truck crops.

CLIMATE

The climate in this part of New Jersey is moderately uniform, neither excessively hot in summer nor intensely cold in winter. The season usually opens 10 days to 2 weeks earlier than in Cape May County in the extreme part of the state, because Gloucester County does not get to any great extent the cold eastern winds from off the coast. The average winter temperature is a little above freezing with very little snow, and it is often possible to plow at different times throughout the winter. The average temperature during the summer is about 66°F.

The distribution of rainfall has a greater influence on truck farming than on most other types of farming. The porous character of the soil of this region requires an even distribution during the growing season, particularly as the crops begin to mature but an excessive precipitation just as the crops mature is sometimes detrimental to the quality of the product. The tomato crop, for example, is often injured by the heavy rains in August, which affect its shipping qualities. Not infrequently half of the crop is unsalable because of this fact.

The diagrams in Figure 2 show graphically the monthly rainfall and the growing season, from the last killing frost in the spring to the first killing frost in the fall for the years included in the survey; also the average rainfall and the growing season for the last 25 years. Since there was no station for recording rainfall in Gloucester County, that represented in the diagram is the average recorded at Haddonfield, Camden County, for 21 years and the 4 years ending in 1917 taken at Philadelphia, Pennsylvania, with the amount recorded at Bridgeport on Delaware Bay, which is a little greater than at points farther inland; hence the average given represents more nearly the actual rainfall in Gloucester County.

The average rainfall for 25 years was 42.8 inches and is quite uniformly distributed. The total rainfall from year to year varies considerably as well as the distribution throughout the year. For the three years of the survey, 1914, 1915 and 1916, the total rainfall was 37.3, 47.3 and 34.5 inches, respectively. The 25-year average shows that the greater precipitation is in August and the rainfall in August, 1915, over 8 inches, was unusually heavy. This seems to be somewhat reflected in the crop yields and farm sales for that year which were below those of the previous and succeeding years. The distribution of rainfall, also, is generally quite favorable for the sweet potato crop, coming at the time of the year when it is most needed. The conditions, moreover, are very favorable for seeding to clover or alfalfa in late summer and for completing the season's work from September to November.

TYPES OF FARMING

Trucking and market gardening with fruit and poultry are the most common types of farming in southern New Jersey. The intensity of one or more of these enterprises depends on the adaptation of soils and market conditions. On a belt of land along the Delaware River from Camden to Mt. Holly and Burlington, peaches, apples and berries occupy an important place in the system of farming. From Woodbury to the Salem-Gloucester County line, this region is devoted almost entirely to growing truck crops and less than 10 per cent of the crop area to fruit. In the eastern part of Gloucester County, extending into Salem and Cumberland Counties, the principal type of farming on the heavier soils is of more general nature—corn, potatoes, late tomatoes and hay with fruit and poultry. Truck crops are grown on more sandy areas.

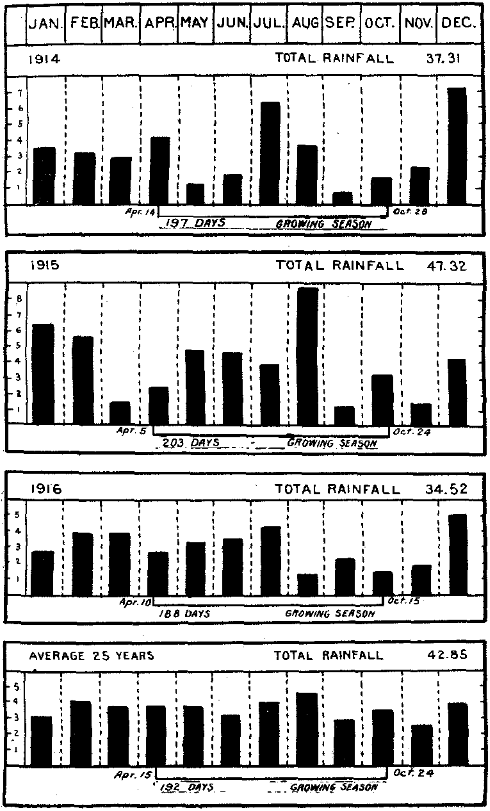

FIG. 2. DIAGRAMS SHOWING RAINFALL IN SALEM COUNTY.

Table 1
Shipments of Fruits and Vegetables from Swedesboro, New Jersey, for 1916

	TOMATOES				SWEET POTATOES		ASPARAGUS	CANTALOUPES		PEPPERS			EGGPLANTS			PEACHES
	Crates	10-quart Baskets	Can-house Stock ⅞ bushel Baskets	Can-house Stock ⅞ bushel Baskets By boat	Hampers	Barrels	Crates	Bushel Hampers	Crates	Crates	Hampers	Barrels	Crates	Hampers	Barrels	Baskets
....							5,951									
....	639						6,820			328						
....	513,040	3,871					458			7,297	6,990			810		1,269
....	68,732	19,922	307,434	300,000	10,253	359		2,014	22,111		13,431			11,304		5,236
....	169				47,934	16,055		170	10,334		2,500	4,895	258	4,485		4,350
....					46,255	19,510					2,489	4,355		2,481	174	98
....					24,528	2,442					5,837	80		117		
....					20,965	827										
1917																
....					9,152	41										
....					14,957	15										
....																
al	582,580	23,793	307,434	300,000			18,229	2,184	32,445	7,625	31,247	9,330	258	19,197	174	10,953

Notwithstanding that western Gloucester County is close to good markets, only a few farmers keep cows more than enough to supply the family with dairy products, because the growing of vegetables is more profitable on these types of soil. Poultry in this region is confined to farm flocks of 100 to 150 hens. A few hogs are kept on nearly every farm, but chiefly for family use.

TRANSPORTATION FACILITIES AND MARKETS

The region studied is provided with excellent transportation facilities for shipping farm produce, there being two principal lines of railroad, the Salem and Penn's Grove branches of the Pennsylvania railroad. The Salem branch extends from Camden through Woodbury and Swedesboro to Salem and reaches a large portion of this region. The Penn's Grove branch extends from Woodbury to Penn's Grove in Salem and parallels the Delaware river through Paulsboro and Bridgeport. In addition to the stations at Woodbury and Swedesboro on the Salem branch there are about six smaller shipping stations and about as many more on the Penn's Grove branch. It means that the hauling distance to shipping points seldom exceeds three or four miles.

The region is also provided with good highways, both stone and hard dirt roads. A macadam road from Camden passes through Woodbury to Swedesboro and from this point to Woodstown, Salem County. There is also a hard road from Woodbury to Penn's Grove and stone or gravel crossroads connecting these main highways. The highway system provides ample facilities for hauling farm produce either to shipping points or to Philadelphia markets.

CROP	Total Number of Carloads Reported	First Date of Shipment	Last Date of Shipment
Asparagus	15	June 6	June 24
Cantaloupes	86	August 9	September 5
Egg Plant	6	August 18	October 4
Peaches	11	July 27	September 5
Peppers	70	July 21	November 6
Sweet Potatoes	793	August ( )	December 30
Tomatoes	1,139	June 30	August 25

Swedesboro is the largest shipping point in this region and the bulk of the early tomato crop is shipped by freight from this station. Table 1 gives the amount of vegetables and fruit shipped by rail in 1916 from this station. The figures are from the records of the Pennsylvania railroad, a local cannery, and a boat transportation company. There were about 300,000 ⅝-bushel baskets of tomatoes shipped by boat to Baltimore, Maryland, and Wilmington, Delaware, canneries and a little over 307,000 baskets received by the local cannery. This can-house stock is mostly manufactured into tomato pulp. A comparatively small acreage of late tomatoes is grown for canning purposes, the amount sold as such being really the "clean up" of the crop after the market price has dropped so that it does not pay to ship them in crates. It will be seen that most of the produce is perishable and is sold as soon as the crop has matured. Sweet potatoes is the only crop held in storage and approximately 10 per cent of this crop is thus held and not closed out until the following July.

In the vicinity of Woodbury, and sometimes from points farther south, most of the vegetables are hauled directly to Philadelphia markets and sold to commission merchants, the farmers paying ferriage or toll charges. Very little, if any, produce is peddled by the farmer.

During the tomato season the farmers drive into the main street of Swedesboro with their tomatoes where buyers bargain with the producers and deliver their loads to the car indicated by the purchaser. It is not unusual for 50,000 crates of tomatoes to be shipped from Swedesboro in one day. No other crop receives so much attention from buyers. Farmers prefer to sell their tomatoes

from Swedesboro but where the hauling distance is too great, the crop is usually shipped on consignment to commission men at New York City or Newark, New Jersey.

The intensiveness of trucking and the magnitude of the business in this region is indicated by the record of shipment in carload lots in 1916, shown in the table on the preceding page. Less than carload shipments were made earlier and later than is shown here.

TENURE

Of the 386 farmers from whom records of their farm business were obtained for the season of 1915, 41 or 10.6 per cent. were cash tenants, 78, or 20.2 per cent, share tenants, and 267, or 69.2 per cent, farm owners. Owners of 22 of the owner farms employed "truckers" to grow on shares one or more crops, usually early tomatoes or sweet potatoes, the owner furnishing the land, manure, fertilizers, and usually machine and horse equipment, the trucker doing all the work and receiving one-third of the crop as his share. If the trucker furnishes more than man labor he often gets one-half of the crop. Twenty-six of the farms operated by their owners rented additional land either for cash or on shares, the land so rented varying from 3 to 40 acres.

AGRICULTURAL HISTORY AND DEVELOPMENT

Southern New Jersey was originally settled about 275 years ago by agricultural peoples of northern Europe, more particularly by Swedes and English. Gloucester County at first included a large part of southern New Jersey and it was not until about 1710 that the boundaries of Burlington, Salem and Cape May counties were established. West New Jersey, a name by which this region was formerly known, was settled by the Swedes about 1638, from whom Swedesboro, the principal town in Woolwich township, received its name.

The Swedes were well established when the English arrived, from whom horses, cows, oxen, sheep, hogs, geese and ducks were purchased, the stock originally being brought over from Sweden. From a history of West New Jersey, written in 1698: "As for corn they have wheat, rye, peas, oats, barley, rice, etc., in vast quantities. Also Indian corn, peas and beans, likewise English hemp and flax. Eating roots—pumpkins, Cashews, watermelons, muskmelons, cucumbers, squashes, carrots, artichokes, potatoes, turnips, garlic onions and leeks grow in greater plenty than in England. As for herbs, they have cabbages, coleworts, Savoys, lettuce, Purslano and other salads in abundance."

Home industries were also prominent at Swedesboro in the early days, and according to Gustafson, a pioneer settler, in 1660, this village, then called Raccoon, had two blacksmiths who made excellent knives, scythes, carts and wagons. The cart and wagon wheels were first made of heavy sections of sweet-gum trees, but later the spokes and felloes were made of oak.

According to Francis Bazely Lee in "New Jersey as a Colony and a State":

"The most characteristic features of the economic development of West Jersey was the establishment of a land-owning class. The ownership of land was at that time an indication of wealth. There grew up a social condition not unlike that of widewater Virginia and Maryland, differing, however, in the fact that amusements, diversions and laxities permitted in the south were absolutely forbidden in West Jersey. But in so far that the men became wealthy farmers and owners of saw and grist mills—and to use up at home the products of their farms, the similarity between West Jersey and Virginia or Maryland is perfect."

From "Our Country and Its Resources" by J. D. McCabe:

"The soil of a greater portion of New Jersey is light and sandy and was for a long time esteemed too poor to justify cultivation but the liberal and judicious use of fertilizers has brought it to a high and remarkable state of fertility, lying so near the great cities of New York and Philadelphia, unusual advantages are offered the farmers of this state for the rapid sale of their crops and as a consequence they are largely engaged in market gardening."

In the early days farming was a self-sustaining agriculture and but little ınd was cultivated or required to supply family needs and satisfy local markets. hiladelphia was then the only outside market, the demand for fruit and egetables was limited and what farm produce reached the outside markets was auled over wagon roads. The crops were grown mostly on meadows along ie streams which had been diked and drained. The land which now produces ne crops of vegetables was then considered too poor for farming and was not .eared. Meadows not in grain or other crops were utilized as pasture.

A little later clover and timothy were grown on uplands, about 1 acre er farm and cut by hand. The value of this hay was soon appreciated, even efore mowing machines appeared, the result being that more of the new land as cleared and utilized; this resulted in the banked meadows being neglected nd they reverted to marshes. When these meadows were used, rye was grown, ut when the acreage of timothy and clover increased, they were planted to heat.

These conditions continued until the beginning of the Civil War when there as a demand for vegetables to feed the army. Consequently, land which had een used in producing timothy and clover was planted to vegetables in all andy soil sections. The growing of wheat was abandoned and the acreage of omatoes, asparagus and general truck crops was increased. The sheep industry eclined, particularly those of animals kept for wool and only a few were reained to take care of the trade in early lambs. The number of hogs also ecreased, because of the low price of pork, and the fattening of cattle declined. n fact, as soon as railroads were built which opened up this region to the arkets of the country there was a rapid transition from a more general type f farming to market gardening and trucking.

The development of this region and the changes that have taken place since 860 are shown in the census statistics given in Table 2.

When the trucking industry began to develop and farming became more inensive, many of the larger holdings were divided and the tendency to smaller nits has continued until the present time. For the same reason the per cent f improved land has gradually increased. The value of land has fluctuated ut on the whole it has remained quite stationary. At no time has dairying een prominent and the cattle kept on these farms are merely for the purpose f utilizing unsalable forage crops. The greatest change in the livestock inustry is shown in the decrease of the number of sheep and swine per farm.

While the acreage of corn per farm has somewhat decreased, there has been nly a slight increase in the total production, which shows the influence of etter methods of culture on crop yields. The same thing holds true with hay. he decrease in the production of hay, however, between 1890 and 1900 as given n table 2 is partly due to the manner of taking the census, as the figures for 890 probably included wild meadow hay, while the figures for 1900 and 1910 ncluded only timothy and clover. The most remarkable change has been the ıcrease in production of early white potatoes and sweet potatoes and the increased valuation of all market-garden crops and fruit.

METHODS OF STUDY

In the late summer and fall of 1915 a study of this region was begun by isiting the farms and obtaining as accurately as possible a record of the year's usiness on these farms, from March 1, 1914, to March 1, 1915, together with n inventory of the farm investment for the beginning and the end of the farm ear. This study was repeated for the two succeeding years, the seasons of 915 and 1916, the records being taken in March or just at the close of the farm ear.

The number of records obtained varied during the 3 years, as it was not lways possible to get a continuous record on the same farm. In order more arefully to study the factors which influence success or failure with this type f farming and the conditions which often lead to a variation of results from ear to year, only those farm records were used in this publication which covered period of 3 years.

Table 2

Census Data of Gloucester County, New Jersey

	1860	1870	1880	1890	1900	1910
Number of farms	1,331	1,336	2,034	1,893	2,225	2,252
Acres per farm	91.8	93.0	72.8	72.4	66.7	62.0
Per cent of improved land	70.6	79.9	80.4	81.8	79.1	76.6
Value of property per farm	$5,982	$8,084	$4,433	$4,373	$3,546	$4,429
Value of land per acre	$65	$87	$61	$60	$53	$71
Number of horses and mules on farms	3,848	4,922	5,189	5,505	5,892	6,156
Number of dairy cows on farms	5,681	5,523	6,985	6,708	6,566	5,817
Number of other cattle on farms	2,993	2,409	2,668	1,897	2,529	2,436
Number of sheep on farms	1,918	2,704	2,913	1,212	102	359
Number of swine on farms	12,442	10,382	13,039	12,164	10,553	8,694
Corn:						
Acreage	......	......	19,156	16,657	18,077	17,226
Bushels	425,033	457,236	675,653	590,602	653,470	598,205
Hay:						
Acreage	......	......	21,716	25,055	22,539	15,966
Tons	21,229	27,805	27,300	37,381	23,792	24,355
Grain:						
Bushels of Wheat	60,997	123,181	108,154	85,027	66,560	20,289
Bushels of Rye	42,139	20,334	27,473	29,358	21,080	15,873
Bushels of Oats	19,419	27,543	29,299	24,619	4,150	7,015
White Potatoes:						
Acreage	......	......	4,282	5,276	5,246	7,149
Bushels	300,847	411,872	353,518	412,508	374,770	876,274
Sweet Potatoes:						
Acreage	......	......	8,951	9,370	8,678	8,857
Bushels	585,756	762,624	977,422	1,072,298	1,054,803	1,444,953
Value market garden crops	$44,500	$249,063	$235,104	$279,970	$457,741	$2,461,705
Value orchard crops	$15,522	$64,186	$32,832	......	$219,684	$264,970

A 3-Years' Study of 125 Farms

The conditions under which truck farms are operated vary so much from year to year that the results obtained from a one-year's study of the farm business in an area may tend to give a misleading interpretation of the condition of farming in that region. For example, the amount of rainfall in the early season may be sufficient to give excellent prospects for a large yield of early tomatoes but excessive rains at the time of harvesting may cause a large proportion of the crop to be unfit for shipping. Also, a lack of rain at the time sweet potatoes are setting may greatly diminish the yield of that crop. Moreover, the fluctuation of prices for truck crops may make considerable difference in the farm income. By extending the study over a period of years, data are furnished that show the yearly variation of items that enter into the farm business which may affect the farm income, the profitableness of one year's farming with another, and define the changes taking place in the agriculture of an area. It was planned to make a 5-years' study of these farms, but conditions arose as the result of the war which gave much uncertainty to a continued study and for this reason it was discontinued at the end of 3 years.[4]

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[4] Certain terms used in this bulletin are here defined:

Farm Investment. The value at the beginning of the farm year of all real estate, machinery, livestock and other investment used to carry on the farm business. It includes the value of the farm dwelling, but not the household furnishings.

Receipts. The amount received from the sale of crops, the net increase from stock, and the receipts from outside labor, rent of buildings, etc. The net increase from stock is found by subtracting the sum of the amount paid for stock purchases and the inventory value at the beginning of the year from the sum of the receipts from stock products, sales of livestock, and the inventory value at the end of the year. If the value of crops or supplies on hand was greater at the end of the year than at the beginning, the difference was considered a receipt.

Expenses. The amount of money paid out during the year to carry on the farm business, together with the value of the unpaid labor performed by members of the family. If the value of crops or supplies at the end of the year was less than at the beginning, this was considered an expense. Household or personal expenses are not included.

Farm Income. The difference between receipts and expenses. It represents the amount of money available for the farmer's living above the value of family labor, provided he has no interest to pay on mortgages or other debts.

Labor Income. The amount that the farmer has left for his labor after 5 per cent interest on the farm investment is deducted from the farm income. It represents what he earned as a result of his year's labor after the earning power of his investment has been deducted. In addition to the labor income the farmer received a house in which to live, fuel (when cut from the farm), garden products, milk, butter, eggs, etc.

Per Cent on Investment. The rate returned on the farm investment after the value of the farmer's labor is deducted from the farm income. It represents what the investment earned after all expenses have been deducted and the farmer has received a fair wage for his labor.

Farmer's Earnings. This amount represents what the farmer receives for his labor and supervision and the value of perquisites, such as food, products and fuel from the farm used in the home and house rent.

Family Earnings. This amount represents the farmer's earnings plus the estimated value of unpaid family labor charged in current expenses.

Animal Unit. In order to compare the different classes of animals and to compute the total amount of livestock on these farms, all stock has been computed in terms of animal units. In this area, one horse, cow or steer was counted as one animal unit; two head of young stock (of the above kind) were counted as one animal unit; 10 sheep, 5 hogs, or 100 chickens were each counted as one animal unit. The number of productive animal units includes all stock except work stock.

Summary of the Farm Business

A brief summary of the farm business conducted on these farms for the years 1914 to 1916 is presented in table 3. The data shown are the averages of 125 farms. The records were divided into four groups according to the area of tillable land with the 3-year average in the last column. The smallest group of 26 farms includes those with 12 to 35 acres, while the largest group of 36 farms has 8 farms with more than 100 tillable acres.

The 125 farms were divided into four groups according to the area of tillable land, the smallest group of 26 farms including those of 12 to 35 acres, while the largest group of 36 farms had 8 farms of more than 100 tillable acres. For a 3-year period the average total area of all farms was 81 acres with about one-third of the area in woodland, waste land and permanent meadows not tillable. The per cent of crop land is about 66 per cent of the total farm area, and this percentage is quite uniform in all the groups, although it is somewhat greater in the group of small farms. These farms have an average of 6.6 productive animal units, of which 3.1 are cows, the remainder being hogs and chickens. A few of the larger farms had dairies, which accounts for the greater number of animal units in the larger group. The operator of the small farm kept an average of about one team of horses, of the medium-sized farm 2 teams, and of the largest farms 3 teams.

The average value of farm land was $122 per acre on farms included in the smallest group, $82 per acre on farms of the largest group, but $97 per acre as the average of the 125 farms. This includes buildings, but not equipment. This, with the value of livestock, machinery, etc., represented a farm investment of $10,445. The average capital represented on the smallest farms is 56 per cent below, while the investment on the largest farms is about 43 per cent above the average of all farms. The average amount of working capital on these farms is $2,596, or about 25 per cent of the total investment.

Market gardening as carried out in this region is definitely crop farming, and on these farms 86 per cent of the total farm income was from the sale of crops, principally early tomatoes, sweet potatoes and asparagus. This income varies from $1,922 with the smallest group of farms, to $5,137 on the largest farms, or an average of $3,637, of which $2,681, or 73.7 per cent, was used for the expenses in connection with the farm business. After deducting the expenses from the receipts, the farm income, or the combined earnings of the investment and the farmer's own labor, was $1,535 as the average of all farms. With good security, capital would ordinarily earn in this region 5 per cent interest, and the farm investment would have earned $522. This amount deducted from the farm income leaves $1,013 for the farmer's own labor and supervision, or his labor income. The small farm with a limited acreage available for crops does not offer the same opportunity for conducting as large a business as is offered by the large farm therefore the average labor income of the group of farms having 35 acres or less of tillable area was but $821, or 35.8 per cent of the average labor income of the group of farms having 75 acres or more.

Usually the farm furnishes a large amount of the food products, such as vegetables, fruit, milk and meat products which have been produced on the farm by the farm and family labor charged under farm expenses. In addition to these products there may be other perquisites, such as firewood and house rent, which should be included in order to compare the farm business with other commercial enterprises. The value of these items may be considered as an addition to the labor income or per cent on investment. These data given in table 26 were the result of a study made the year before on 118 farms in this region. The total value of the food, fuel and the use of dwelling—the three most important items of the farmer's living—amounted to $453 per family, of which 60.9 per cent was for food and 35.7 per cent for fuel. Adding this amount to the labor income gives $1,466, which represents the farmer's earnings. Since the farm was charged for labor by members of the family which the farmer did not pay, adding this amount, or $146, to the farmer's

Table 3

Summary of the Farm Business of 125 Farms in Gloucester County, New Jersey

Average of 3 years, 1914-1916

	Farms with Total Tillable Area of				Average of all Farms
	Less Than 35 Acres.	35.1 to 55 Acres.	55.1 to 75 Acres.	75.1 Acres and Over.	
Number of farms	26	33	30	36	125
Crop area per farm (acres)	24.6	41.0	57.9	81.4	53.3
Number of productive animal units	3.5	4.6	6.4	10.7	6.6
Number of work stock	2.5	3.7	4.9	5.8	4.3
Investment	$5,844	$7,986	$11,768	$14,920	$10,445
Working capital	1,470	1,952	2,805	3,826	2,596
Receipts:					
Crops	$1,922	$2,767	$4,281	$5,137	$3,637
Livestock and livestock products	280	312	367	757	447
All other receipts (including increase of inventory)	101	75	205	148	133
Total receipts	$2,303	$3,155	$4,853	$6,042	$4,217
Expenses:					
Current	$1,357	$1,890	$2,895	$3,568	$2,504
Depreciation (except live stock)	109	133	184	198	159
All other expenses (including decrease of inventory)	16	17	12	29	18
Total expenses	$1,482	$2,041	$3,091	$3,795	$2,681
Farm income	$821	$1,116	$1,762	$2,247	$1,535
Interest at 5 per cent	292	399	589	746	522
Labor income	$529	$717	$1,173	$1,501	$1,013
Food products from farm used in home *	185	257	286	354	276
Fuel from farm used by operator *	9	15	17	18	15
House rent *	122	154	169	197	162
Farmer's earnings	$845	$1,143	$1,645	$2,070	$1,466
Estimated value of family labor	112	174	153	172	146
Family earnings	$957	$1,317	$1,798	$2,242	$1,622
Estimated value of operator's labor	$444	$432	$552	$489	$480
Per cent return on investment**	7.3	9.4	10.5	12.2	10.0

* From study of 118 farms in Gloucester county for 1913.

** Does not include perquisites from the farm.

earnings gives $1,466, which represents the amount available for the living of the farmer and his family, provided there is no indebtedness against the farm.

A large number of records were taken for only 2 successive years, but are *not* included in this bulletin. The 125 usable records for 3 years are from farms that are quite representative of all those in the region, and the results derived from the study of this group, whether by years or for the entire period, should prove a source of valuable suggestion for other farmers in the community in organizing and operating their farms and to truck farmers in other regions.

The capital invested in the business only slightly increased each year, chiefly from improvements made or additional land or equipment purchased. This increase amounted to an average of $530 with the group of farms having the largest acreage.

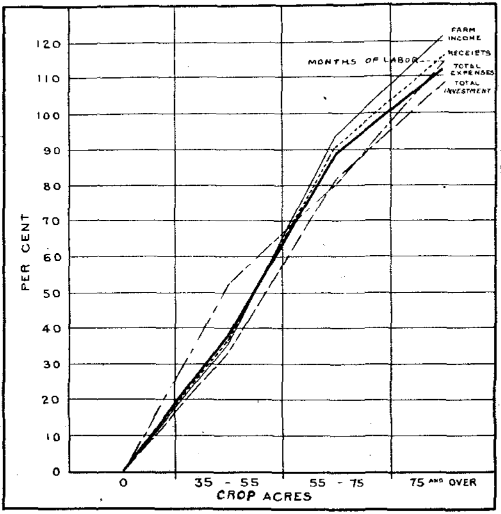


FIG. 3. DIAGRAM SHOWING RELATION OF SIZE OF FARM TO FARM INCOME, LABOR, RECEIPTS, EXPENSES AND INVESTMENT.

Climatic conditions strongly influence crop production and farm incomes. The second year of this study was more unfavorable and the incomes from the smallest and largest groups of farms, particularly, were 6.8 per cent and 12.8 per cent less, respectively, for this season. Both market and weather conditions in 1916 were very favorable and the increase over 1915 of the total crop incomes was 31.0 per cent and 40.7 per cent, respectively, for the same groups of farms, or a 39.6 per cent increase on all farms. The first year was

more nearly a normal season and in a measure the decrease the second year was due to seasonal conditions which affected the quality of early tomatoes, rendering a certain amount unfit for shipping. Sweet potatoes and asparagus, on the other hand, were the least affected by these conditions. These results show what may be expected with this type of farming and that a study for a series of years will give the most accurate status of the trucking business.

The farm expenses increased each year and the average increase of the 125 farms for the three years was $245, or 9.5 per cent. The amount spent for manure and fertilizers remained quite stationary, but the larger crop production for 1916 required a greater amount of labor in harvesting.

The farm profits, whether measured by the labor income or the per cent on the investment, varied widely from year to year. The average labor income for all farms was $904 for 1914, $443 for 1915, and $1,692 for 1916. This shows a decrease of 56 per cent in 1915 and an increase of 67 per cent in 1916 from the 3-year average.

Table 4

Utilization of Land on 125 Farms in Gloucester County, New Jersey

Size of Farm (Tillable Area)	Number of Farms.	Total Area.	Tillable Area.	Crop Area.	Meadow not Tillable.	Total Pasture.	Idle Crop Land.	Woods and Waste.
		acres	acres	acres	acres	acres	acres	acres
35 acres and less ..	26	35.7	26.1	24.6	2.4	1.0	0.8	6.9
35.1 to 55 acres ..	33	61.5	45.7	41.0	3.0	4.3	2.6	10.6
55.1 to 75 acres ..	30	89.3	65.0	57.9	3.8	7.2	3.9	16.5
75.1 acres and over	36	124.0	97.7	81.4	7.4	12.9	6.3	16.0
Average	125	80.8	61.2	53.3	4.3	6.8	3.6	12.8

Size of Business

The size of the farm business may be measured in a number of ways, so long as we deal with fairly uniform conditions. Under such conditions farms may be compared by the acreage of crops grown, months of labor, or capital invested. Receipts from crop sales and total expenses are not as accurate standards of measurement because they are based on result rather than cause. Figure 3 is a graphic illustration representing the trucking business in Gloucester county. The relation of several important factors to size of farm is shown by the different divergent lines. The scale on the left indicates the percentage increase of these factors with the different groups of farms assorted by size as given at the bottom of the chart.

It will be noticed that these lines run in the same general direction and that using the total receipts or total expenses as a standard for these farms would give approximately the same result as a measure by total investment or total labor. When practically all of the crop land is devoted to truck, the total area is a fairly accurate measure, but when there is a large acreage of corn or hay, as is often the case in this region, there is a greater variation in the total labor requirement; hence, the measure of the size of business on a total labor basis would be more accurate.

The Farm Area

The average farm had an area of 80.8 acres of which 66 per cent was planted to crops, 4.5 per cent fallowed or idle, 5.3 per cent in meadow not tillable, 8.4 per cent in pasture and 15.8 per cent in woods and waste land.

Of these 125 farms, 72.3 per cent were operated by their owners, 24.0 per cent were rented on shares, and 3.7 per cent rented for cash. Seventy-eight per cent of those rented had an area of more than 60 acres and 87 per cent of those were operated by share renters. These figures seem to indicate that those renting farms realize the need of handling a good-sized business in order to make it pay. An average of nine of these farms employed "truckers," that is, persons who handled one or more crops or shares, the owner furnishing land, all materials and often the equipment, while the trucker furnished the labor.

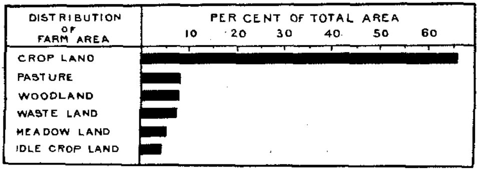


FIG. 4. DIAGRAM SHOWING DISTRIBUTION OF FARM AREA.

Table 4 gives the utilization of land by size of farm. There was not much variation from year to year in the average of these groups of farms, the difference being partly due to the farm owner renting additional land, renting out a field, or letting a few acres remain idle. The area of crop land remaining idle varies considerably in a few cases, one of the third group of farms having 20 acres of crop land remaining idle in 1916, but the average difference of this group of 30 farms was less than 2 acres. This variation is generally greater with market gardeners than with general farmers.

Figure 4 gives the percentage distribution of farm area on 125 farms. It shows that practically all the tillable area is utilized as crop land and that all areas profitable for farming have been cleared and planted. There is very little difference between the proportion of pasture, woods or waste land and the amount of crop land not cultivated is small in comparison with other regions. Waste land is about in equal proportion to woodland and includes rough or poor stretches of sandy land, or irregular-shaped areas, which makes it impracticable to use as crop land. Some of the waste land, moreover, was undoubtedly cleared and tillable at one time but has been allowed to grow up to brush or weeds because it was unprofitable. Such land is often pastured.

The groups of farms with an average of 124 acres had 7.2 per cent more tillable land than the average of the three other groups, which showed very little variation in this respect. These larger farms carried more livestock to use up unmarketable roughage and had more pasture land which was mostly

tillable. This region is traversed by a few large creeks and a greater number of smaller branches, which account for quite an area of meadow, pasture and waste land on some farms.

The Crop Area

Certain economic factors such as the labor supply and seasonal distribution of land, the adaptation of different truck crops to certain types of soil, the effect of weather conditions on crop yields and quality of farm produce, and market prices, must be considered in the selection of crops and the acreage of each grown. A great deal of hand labor is required in harvesting and marketing many of the crops which makes extra labor absolutely necessary at certain periods of the summer. This problem has been worked out quite successfully by contracting for Italian and other labor, but in order to make satisfactory arrangements the farmer agrees to keep such labor continuously employed. The soils, moreover, may vary considerably, requiring more than one crop to be planted on the same field, which makes a definite rotation more often impossible. The probability of receiving a fair price for the principal crops and the prospects of a sufficient amount of rainfall at the right time to force the crop for early market also has been a factor in determining the kind and distribution of crop enterprises.

Table 5 gives the crop distribution by area on 125 farms, grouped according to the size of farm. The four principal crops grown by areas are hay, corn, sweet potatoes and early tomatoes, or 9.92, 9.92, 11.83 and 8.95 acres per farm, respectively. The figures for hay include clover and timothy, cowpeas and soybeans and hay made from grains such as oats, rye or wheat and millet. The average acreage in hay other than clover and timothy is insignificant as these crops occurred only on a few farms and were planted to supplement the shortage of regular hay. Alfalfa is being grown only on a few farms, but the results indicate that this crop can be successfully grown in this region, particularly on the heavier soils under good cultural methods. Farmers should be encouraged to increase the acreage of this crop where possible because of its value from a nutritive standpoint, for its influence in improving soils and because the annual yield is usually twice as much or greater than ordinary hay. The acreage of hay varies but little from year to year and is not over one per cent of the total crop area.

Corn is grown to furnish grain for work stock, poultry and hogs and to some extent for cattle and the stover for feed and bedding. Very little corn is sold. The area planted happens to be the same as the area in hay crops. In planning for this crop the farmer's point of view is (a) to furnish as much grain for feed as possible and (b) to utilize for corn all the available land not in truck crops provided this land will give a profitable yield of corn.

Sweet potatoes and early tomatoes are the two market crops which seem to pay best in this region and which are the principal sources of income on these farms. The cropping system is planned with as large an acreage as possible of these crops. Sweet potatoes seems to be a very dependable crop and it does not conflict in labor requirements to any great extent with other truck crops in planting and harvesting. The acreage scarcely varies from year to year and the light sandy soils produce "sweets" of good quality. For these reasons the average acreage is larger than for any other crop and occupies almost one-fourth of the crop area. Early tomatoes is second in importance from an acreage standpoint, occupying about one-fifth of the crop area.

Asparagus is an important source of income on many farms. The average area planted to this crop, however, was but 2 acres. Forty per cent of these farms produced asparagus and if only these farms are considered the average area is 5.2 acres per farm. The group of small farms had 14 per cent more asparagus than the average farm and 33 per cent more than farms with a tillable area of 55 acres or more.

White potatoes are grown as a truck crop on 68 per cent of these farms. Because this crop requires a little heavier and more moist soil than most other truck crops, the fields must be carefully selected. Only 5.1 per cent of the crop land in western Gloucester county is planted to this crop. In the eastern and southeastern parts of the county there is a larger acreage of white potatoes and a much smaller acreage of sweet potatoes. Using only the

records of farms on which this crop is grown, the average is about 4 acres, or 7.4 per cent of the crop area.

The area in cantaloupes is 1.72 acres, or 3.2 per cent of the land in crops This crop was found on 40 per cent of these farms, the larger farms having 17

Table 5

Distribution of Crop Area on 125 Farms in Gloucester County, New Jersey

Average of 3 years—1914-1916

	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75 acres and over	All farms
Number of farms	26	33	30	36	125
	acres	acres	acres	acres	acres
Hay, clover, timothy and annuals	2.85	7.26	10.02	17.71	9.92
Hay, alfalfa	0.36	0.44	0.90	1.24	0.76
Small grain	0.25	0.62	0.44	2.52	1.03
Corn	4.25	7.48	11.00	15.68	9.92
White potatoes	0.79	2.37	3.45	3.85	2.71
Sweet potatoes	5.13	10.04	12.95	17.69	11.83
Asparagus	2.18	1.52	2.06	2.29	2.00
Tomatoes	4.38	6.80	10.59	13.09	8.95
Peppers	0.54	0.96	0.71	0.75	0.75
Eggplant	0.21	0.05	0.17	0.11	0.13
Cantaloupe	0.88	0.69	2.00	3.09	1.72
Watermelons	0.26	0.40	0.51	0.77	0.50
Peaches	0.51	0.39	1.30	0.63	0.70
Apples	0.65	0.90	0.98	1.29	0.97
Other fruit	0.49	0.29	0.37	0.62	0.44
Other truck crops	0.90	0.78	0.48	1.59	0.96
Totals	24.63	40.99	57.93	82.92	53.29

per cent greater acreage than the small farms. The average of only those farms having cantaloupes was 3.7 acres. The average varies considerably in the different years and the land devoted to this crop in 1916 was 46 per cent greater than in 1914. This increase may be due to several causes, such as higher prices, the influence of the auto truck in hauling directly to Philadelphia markets and a better knowledge of cultural methods in combating insects and plant diseases.

Table 6

Percentage distribution of crop area on 125 farms in Gloucester County, New Jersey

Average of 3 years, 1914-1916

	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75 acres and over	All farms
Number of farms	26	33	30	36	125
	per cent	per cent	per cent	per cent	per cent
Hay, clover, timothy and annuals	11.6	17.7	17.3	21.4	18.0
Hay, alfalfa	1.5	1.1	1.6	1.5	1.4
Small grain	1.0	1.5	0.8	3.0	2.0
Corn	17.3	18.2	19.0	18.9	18.6
White potatoes	3.2	5.8	6.0	4.6	5.1
Sweet potatoes	20.8	24.5	22.3	21.3	22.2
Asparagus	8.8	3.7	3.6	2.8	3.8
Tomatoes	17.8	16.6	18.3	15.8	16.8
Peppers	2.2	2.3	1.2	0.9	1.4
Eggplant	0.8	0.1	0.3	0.1	0.2
Cantaloupe	3.6	1.7	3.4	3.7	3.2
Watermelons	1.1	1.0	0.9	0.9	1.0
Peaches	2.1	1.0	2.2	0.8	1.3
Apples	2.6	2.2	1.7	1.6	1.8
Other fruit	2.0	0.7	0.6	0.8	0.8
Other truck crops	3.6	1.9	0.8	1.9	1.8

The other crops shown in table 5 are grown in much smaller amounts more for the purpose of utilizing land and labor most efficiently. Probably another reason why these crops are not more generally grown is that buyers come to Swedesboro and other shipping points to purchase tomatoes, white and sweet potatoes while other crops are either hauled directly to Philadelphia markets or shipped to commission merchants in different cities. The operators of 51 farms, or 40.5 per cent, raised peppers with an average of 1.8 acres on those farms where this crop was grown. Only 13, or 10.4 per cent, of the 125 operators raised eggplant each year of the 3-year period; 22 operators, or 17.6 per cent, grew watermelons; 18 operators, or 14.4 per cent, peaches, and 21 operators, or 16.5 per cent, apples outside of a few trees for family use. *Most of the peaches were on farms having less than 75 tillable acres.* Of miscellaneous truck crops, lima beans were raised on 14 farms; onions on 9 farms; green onions on 3 farms; string beans on 4 farms; early cabbage on 2 farms; cucumbers on 4 farms; peas on 1 farm; lettuce on 1 farm; carrots on 1 farm; celery on 1 farm; turnips as a second crop on 8 farms; spinach on 1 farm; strawberries on 9 farms, and pumpkins on 6 farms. Watermelons, pumpkins and cabbage were more often grown on large farms and strawberries or other small fruit on small farms.

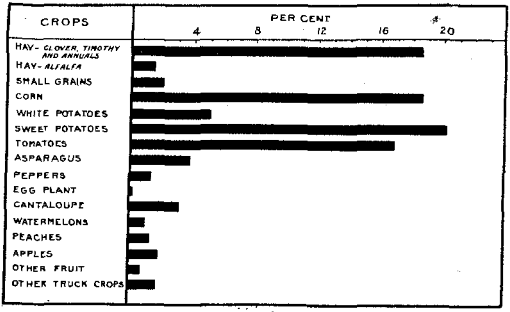


FIG. 5. DIAGRAM SHOWING DISTRIBUTION OF CROP AREA.

Table 6 gives the percentage distribution of crop area by size of farm and for the 125 farms. The largest group of farms had 90 per cent more land in hay than the smallest group of farms. This is to be expected, because more livestock was kept on these farms. The operators of several of the smaller farms purchased hay in order to utilize the land for truck crops. Small grain was grown mostly on the larger farms. The percentage variation in the area of corn was not over 1 per cent in any group for the different years and not as much as would naturally be expected. White potatoes decreased in area from the first to the third years of this survey with all groups of farms. On the other hand, the area in asparagus gradually increased during this period. The area of sweet potatoes fluctuated to some extent, but this was mostly on farms having less than 55 tillable acres. On the largest farms the acreage of tomatoes was increased each year, but there was a much smaller variation on all other farms. The percentage variation during this period with all other truck crops was very slight.

Seven and one-half per cent of the farmers raised strawberries with an average acreage of 2.7 acres each. On one of the large farms 12 acres were

in this crop. Fourteen and four-tenths raised peaches with an average of 4.9 acres. One in the group of large farms raised 10.2 acres as the average for three years. Only three farms had more than 7 acres each of apples.

Figure 5 graphically shows the average percentage distribution of crop area on the 125 farms. It emphasizes more prominently the crops which have made *farming* in this region most successful.

Table 7

Average Yields of Crops per Acre for Three Years on 125 Farms in Gloucester County, New Jersey

Crop	No. of Records (3 years)	Average Yield Per Acre
Corn	348	39.9 bushels
Wheat	22	18.2 bushels
Clover and timothy hay	308	1.68 tons
Alfalfa hay	56	2.91 tons
White potatoes	256	175.9 baskets*
Sweet potatoes	351	227.6 baskets
Tomatoes	358	352.7 baskets
Asparagus	144	60.6 crates
Peppers	152	463.0 baskets
Eggplant	39	548.0 baskets
Cantaloupe	173	278.0 baskets
Watermelons	66	564.3 melons
Lima beans	41	254.4 baskets
Onions	28	227.2 baskets
Green onions	9	204.4 baskets (in bunches)
String beans	13	148.3 baskets
Cabbage	22	307.6 baskets
Cucumbers	11	179.8 baskets
Turnips	25	175.1 baskets
Pumpkins	18	9,106.0 pumpkins
Peaches	54	206.7 peach crates
Apples	52	117.0 baskets
Strawberries	28	72.7 crates

* A basket held five-eighths of a bushel.

Crop Yields

Table 7 gives the average yield per acre of the principal crops grown. A number of crops, such as peas, lettuce, carrots, celery, spinach and squashes were grown on so few farms that the average would not represent the normal yield. Several crops, such as white potatoes, sweet potatoes and tomatoes were sold in bushels, baskets, crates or barrels, but were all reduced to the equivalent of a 5-8 bushel basket in determining the yield per acre. The figures given, covering a period of three years, represent fairly normal yields. Errors on an individual farm do not occur so often in the estimated returns from farm sales as in the acreage of the crop grown. As a rule the farmer knew quite accurately what was sold and in many cases the figures given were taken from the farmer's books. In estimating yields, the figures used included what was reserved for family use, for livestock and for seed. In a few cases allowance was made for a portion of the crop not salable, as in the case of tomatoes rendered unfit for shipping because of rainy weather.

In the different groups by size of farms the yields varied very little with corn, grain, hay and other forage crops. The 36 largest farms produced an 11 per cent greater yield from white potatoes, 6.2 per cent from tomatoes, 5.8 per cent from asparagus, 22 per cent from lima beans, and 5.2 per cent from onions than the 26 smallest farms. On the other hand, the group of small farms produced a 10.1 per cent greater yield from peppers, 50.3 per cent from eggplant, 17.0 from cantaloupes, 37.6 per cent from watermelons and 62.0 per cent from peaches. There was little difference in the yield of sweet potatoes. Business-like methods in farm operations, the efficiency of labor and machinery, and the methods of farm practice in the culture of crops, particularly in the intelligent use of manure, fertilizers, cover crops and tillage methods, undoubtedly exert the greatest influence in maintaining crop yields. The data do not show that the average small farm is making any better yields than the large farm.

Table 8

Yields per acre of the Principal Farm Crops on 125 Farms for Each of the 3 Years, 1914-1916

Crop	1914	1915	1916
Corn	44 bushels	34 bushels	42 bushels
Clover and timothy hay	1.41 tons	1.92 tons	1.68 tons
White potatoes	163 baskets	179 baskets	188 baskets
Sweet potatoes	239 baskets	260 baskets	184 baskets
Tomatoes	260 baskets	254 baskets	397 baskets
Asparagus	57 crates	65 crates	59 crates

Table 8 shows the variation in yields per acre for the 3-year period. It partly explains why the labor incomes in 1915 were less than in either 1914 or 1916. By referring to the climatic chart (fig. 2), it will be seen why the tomato crop fell down in 1914 and 1915, probably on account of the excessive amount of rain in the late growing and harvesting seasons. It may also explain why the yield of sweet potatoes in 1916 was less than the yield in either of the other years. The distribution of rainfall in 1916 was more ideal for most crops, but the lack of rain in the fall of that year, while favorable for harvesting late crops, was insufficient to mature the sweet potato crop fully. It goes to show what must be expected with this type of farming, and that the records of any one year should not be interpreted as the results of a normal season. The average of the three years is much nearer to what can be expected in the trucking region along the Atlantic Coast for a series of years.

Table 9 shows the crop index, or the variation in crop yields on a percentage basis, of all the crops on the farm as compared with the average yields in the community. It indicates in general that the crop yields on the large farms are a little better than the yields on the small farms, though the small farms maintained the average of the community. Operators of the large farms probably make more efficient use of capital, labor and machinery.

Cropping Systems

The cropping system is usually arranged to give the most favorable conditions to the principal market crops, tomatoes and sweet potatoes, and furnish corn and hay for livestock. Peppers, eggplant and the more perishable truck crops are generally of secondary importance and are more often planted to utilize the labor between the periods when extra labor is needed for the principal crops. This *region is so cut up by two railroads, several main roads* and a number of cross-roads that most farms have very irregular boundaries and very few fields of equal area so that it is more difficult to establish a definite rotation, though a regular succession of crops is generally followed. There seems to be a general opinion that no crop should be planted the succeeding year on the same field. As a rule the *succession of crops follows no regular* order, but the crops are planted on fields best suited for the crop and the acreage desired. A large number of farmers arrange the cropping plan in the following order:

1. Corn.
2. Sweet potatoes.
3. Early tomatoes.
4. Clover and timothy hay.

Table 9

The Relation of Crop Index to Size of Farm in Gloucester County, New Jersey

Size of Farm	1914	1915	1916	Average for 3 years
35 acres and less, tillable ..	100	100	100	100
35.1 to 55 acres, tillable ..	95	101	95	97
55.1 to 75 acres, tillable ..	101	101	103	102
75 acres and over, tillable ..	105	102	101	102

Sometimes the hay field is kept down the second year and pastured. Seldom is hay cut two years in succession; the exception would be on farms with heavier soils and where more livestock is kept. When the soils are better suited for white potatoes, this crop takes the place of sweet potatoes. Both tomatoes and cantaloupes are well adapted for August and early September seeding to clover and timothy, as these crops are usually manured and harvested in time for seeding. Peppers and eggplant may be planted as a part of the field of sweet potatoes to be followed by tomatoes, or they may occupy a part of the field of tomatoes. In more intensive culture corn and hay may be left out and sweet potatoes alternated with tomatoes, occasionally planting the field to a crop of cowpeas or soybeans to improve soil conditions and maintain crop yields. *Asparagus may be considered a permanent crop, as it takes about* 3 years to get the field in full bearing condition, after which it may be cut 6 to 10 years and occasionally longer, depending upon the way the field has been handled. The most favorable location and quality of soil is selected for the crop. Strawberries do well on sandy types of soil, particularly on low areas

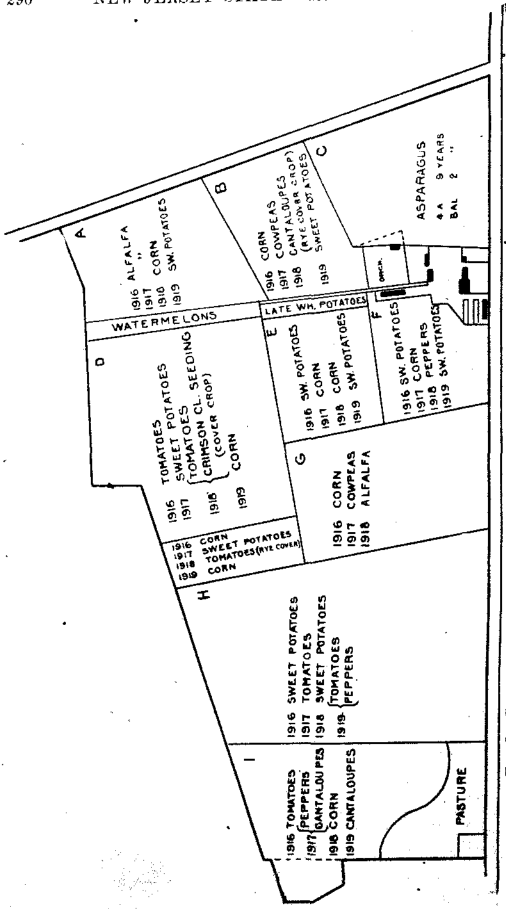


FIG. 6. CROPPING SYSTEM AND ARRANGEMENT OF FIELDS ON A SMALL FARM NEAR SWEDESBORO.

along the streams where there is moisture enough to supply the crop at the most critical time. This crop may also be rotated with more general crops.

In planning a cropping system there can be greater freedom in the arrangement of crops where stable manure is applied and green-manure crops utilized to furnish humus-making material, supplemented with commercial fertilizers. Where the crop area can be divided into fields of practically equal area, there should be no difficulty in arranging a definite rotation of corn, sweet potatoes or white potatoes, tomatoes and hay and a secondary rotation of other truck crops in smaller areas on fields which do not conveniently come into the regular rotation. Alfalfa, to a limited extent as a hay crop for horses and cattle, can be profitably grown on most truck farms, cutting out clover and timothy and planting a cover crop of rye and vetch or crimson clover to turn under as green manure for corn or truck crops. The farmer inexperienced with alfalfa should at first plant a small area, as failures often occur unless the proper methods are followed. But even on sandy soils in this region alfalfa has been grown successfully, provided the field has been prepared previously by turning under green crops or other humus-making material.

In order more clearly to describe the cropping systems on different types of truck farms a few farm plans follow, showing the arrangement of the fields and the crops grown for one or more years:

Figure 6 gives the field arrangement and cropping system on a medium-sized farm near Swedesboro which is quite representative of the farms in this area. It consists of 71 acres, of which 63½ acres is the crop area, about 2 acres in pasture and the balance in home grounds, roads, etc. The crop acreages for 1914 and 1915 were as follows:

	1914 acres	1915 acres
Corn	10	10
Early tomatoes	15	15
Late tomatoes	6	½
Asparagus	4	4
Sweet potatoes	16	21
Cantaloupes	2	..
Alfalfa	4	4
Cowpeas for hay or green manure	6	4
Orchard	½	½
Rye cover crops	10	15

The crops for 1916, 1917 and 1918 and the proposed crops for 1919 are indicated in Figure 6. It will be noticed that the succession of crops varies with each field. Field "A" was permanently in alfalfa for 6 years followed by corn in 1918, then sweet potatoes and other truck crops. In the meantime, field "G" was being prepared for alfalfa by growing cowpeas in 1917 and seeding down immediately after this crop was harvested for hay. Field "H" has been planted to sweet potatoes and tomatoes alternatively for a number of years, being planted occasionally in the tomato field. Good soil conditions have been maintained by planting rye or crimson clover cover crops in the tomatoes on all lighter soil areas to be turned under for sweet potatoes or corn. Stable manure is generally applied for tomatoes. Field "D" has a 3-year rotation of tomatoes, sweet potatoes and corn or sweet potatoes, tomatoes and corn according to field conditions. Corn or sweet potatoes is usually preceded by a cover crop. The rotation on field "B" is corn, cantaloupes and tomatoes. It will be noticed that this is varied, cowpeas or an extra crop of cantaloupes being introduced as desired.

The principles of crop selection, combination and rotation involves certain economic factors which the successful trucker unconsciously solves. From his experience he determines the suitability of crops to the soil variations in order to maintain maximum crop yields, supplementing soil deficiences with stable manure, green-manure crops and fertilizers as needed. The cropping system on this farm illustrates very clearly how many things must be left to

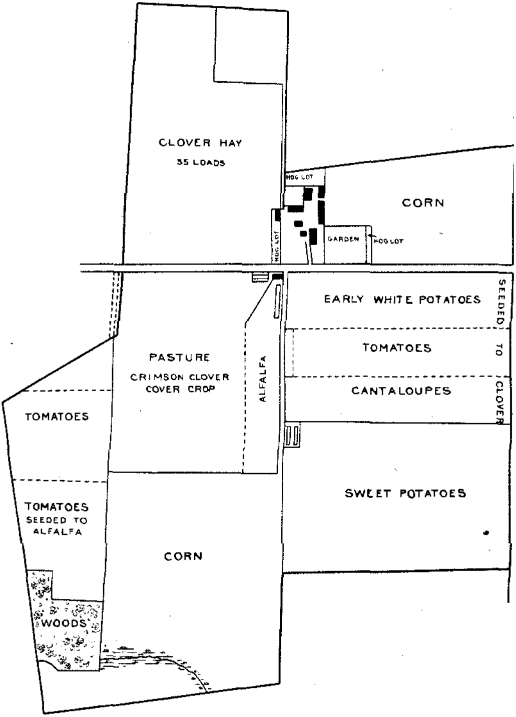


FIG. 7. MAP ILLUSTRATING A DEFINITE ROTATION OF CROPS ON FIVE FIELDS

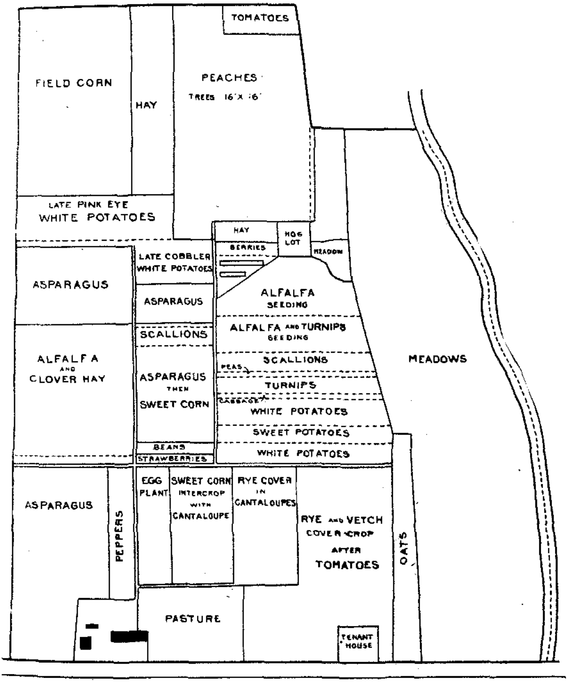


FIG. 8. MAP ILLUSTRATING A ROTATION FOR AN INTENSIVE TRUCKING SYSTEM.

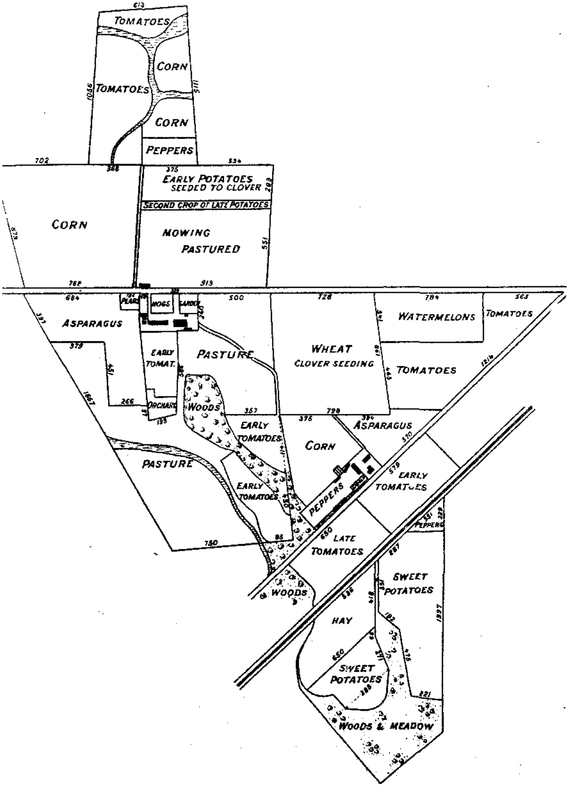
the judgment of the farmer. The owner of the farm in figure 6 is a young man who has owned the farm since 1913. His income from crops in 1916 was $6,400 and the current expenses for that year were $3,239, of which $1,178 was for labor.

Figure 7 shows a map of a farm containing about 86 acres, of which about 8 acres consists of woods and home grounds, leaving about 78 acres for crops. It is representative of the larger group of farms and illustrates splendidly a definite rotation cropping system which is more the exception than the rule in Gloucester County. This farm is very efficiently managed with a minimum of regular help and extra labor only for tomatoes, sweet potatoes and cantaloupes. The plan is given particularly to show how many farmers in this region could establish a definite rotation system by a little rearrangement of fields which would greatly simplify the farm plan. The layout of this farm is such as to make 5 rectangular fields with an average of 12 to 13 acres each. The rotation consists of (1) corn; (2) sweet potatoes; (3) tomatoes and cantaloupes; (4) clover, and (5) pasture. It is somewhat varied according to the character of the soil, white instead of sweet potatoes being grown on heavier areas and for the same reason white potatoes often taking the place of tomatoes. Clover with a little timothy is cut for hay and this field pastured by cattle and sometimes by hogs in the latter part of the season and the early summer of the following year. It is then broken and seeded to crimson clover which is turned under the following spring, thus eliminating the application of manure for corn. Two additional fields containing about 14 acres are utilized as needed for corn, hay or truck crops, but with no definite cropping system. Manure is purchased and with that made on the farm is applied for tomatoes, cantaloupes and sweet potatoes. This farmer makes a specialty of hogs which return a good income. These hogs have the run of the orchard and lot adjoining the buildings and utilize the waste from truck crops.

Figure 8 illustrates a more intensive trucking system with a greater variety of market-garden crops. It is representative of those farms situated nearer the large markets where produce is hauled directly to commission houses, and it is a type more commonly found near Woodbury. The operator owned 50 acres purchased in 1915, and that year rented in addition 12 acres and again 6 acres in 1916, giving 52 and 46 tillable acres, respectively, for the two years. Of this area about 41 acres were used for crops.

Several areas were second-cropped, and most of this land was planted with cover crops of rye, crimson clover or rye and vetch. The average acreage in crops raised in 1915 and 1916 are as follows:

	Acres Grown in 1915	1916
Clover and timothy hay	....	2.5
Meadow hay	8.0	8.0
Field corn	5.5	3.5
Field corn, second crop	2.5	....
Fodder corn, second crop	....	2.5
Early white potatoes	10.0	3.5
Early white potatoes, second crop	....	1.8
Late white potatoes, second crop	1.0	2.0
Late white potatoes, second crop, for seed	0.5	0.5
Sweet potatoes	1.0	1.8
Tomatoes	4.0	4.0
Asparagus	9.0	9.0
Peppers	0.5	0.3
Cantaloupes	6.0	3.0
Eggplant	4.0	2.0
Cucumbers	1.0	0.5
Onions	....	0.5
Squash	....	0.5
Early cabbage	0.5	....
Late cabbage, second crop	1.0	1.0
Apples	1.5	1.5
Peaches	10.0	10.0
Rye cover crop	16.0	25.0
Crimson clover cover crop	4.0	


TOMATOES
CORN
TOMATOES
CORN
PEPPERS
EARLY POTATOES
SEEDED TO CLOVER
SECOND CROP OF LATE POTATOES
CORN
MOWING
PASTURED
PEARS
HOGS
GARDEN
ASPARAGUS
EARLY
TOMAT.
PASTURE
WHEAT
CLOVER SEEDING
WATERMELONS
TOMATOES
TOMATOES
ORCHARD
WOODS
EARLY
TOMATOES
ASPARAGUS
CORN
PASTURE
EARLY
TOMATOES
EARLY
TOMATOES
PEPPERS
LATE
TOMATOES
PEPPERS
WOODS
SWEET
POTATOES
HAY
SWEET
POTATOES
WOODS & MEADOW

The farm represented in Figure 8 is well laid out for the type of farm and the drives are arranged to reach easily every field, thus saving much time. The acreage of asparagus is being reduced for the reason that cutting and bunching come at a time when the help is needed to put in other crops and it is difficult to get extra help just for this crop. The dotted lines show divisions of area which have been double-cropped. There are no permanent field divisions except with peaches and asparagus, the lines being shifted in order to suit the crop to soil conditions and acreage. Fortunately, the soil throughout the farm is a fine sandy loam which simplifies the problem. The meadow overflows and is not tillable, yet produces hay for horses and other stock of fair quality.

One of the most interesting features of the management of this farm is the attention given to cover crops. Scarcely any field is left bare over winter but is seeded to rye, rye and vetch and sometimes crimson clover, the seed being sown in the standing crops. There is scarcely a crop that is an exception to this rule, and even asparagus has its cover crop. Probably one secret of success on this farm is the result of filling the soil with humus-making material, which also furnishes plant-food. Rapid improvement is being made in the character of the soil which is shown by the color and texture of the soil and increased crop yields and incomes.

The crop sales for the first two years that the owner operated the farm, 1915 and 1916, were $5,722 and $5,740, respectively, but the sales from poultry, other livestock and miscellaneous receipts in 1916 amounted to $407 above those received in 1915. The labor income for the two years averaged $3,561 for the two years.

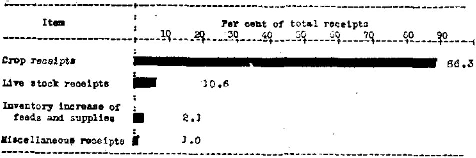


FIG. 10. PERCENTAGE DISTRIBUTION OF RECEIPTS ON 125 FARMS IN GLOUCESTER COUNTY.

Figure 9 is the map of a farm which combines dairying with truck. It consists of two separate farm units with two sets of farm buildings but conducted under one management. The 60-acre unit is located along the Salem branch of the Pennsylvania railroad and is better adapted to trucking, while the upper unit of 120 acres has some rough low-land pasture and some fields with heavier soils which make the farm better suited for dairying. In only a few instances are dairying and trucking combined in this region and usually only when the general farm layout, topography and character of soils make the farm adapted to keeping livestock.

The farm map is given, not so much to illustrate the type of farming and cropping system, as to show the location in relation to the public roads and railroads. In this case they cut the farm so as to make it difficult to handle labor and machinery efficiently. Not only this, but some of the fields are crossed by small streams, badly washed and untillable areas which make the crop area very irregular. This farm is not the exception in this respect, but represents conditions found on many farms in the region.

The upper farm of 120 acres carries about 16 head of cows, and in addition to the forage crops, corn and small grain, asparagus, tomatoes and often other truck crops are grown. The rotation practiced, as far as possible, is as follows: (1) corn; (2) white potatoes, sweet potatoes or tomatoes; (3) wheat; and (4) hay. On the lower farm the succession of crops has generally been (1) corn; (2) sweet potatoes; (3) early tomatoes; and (4) hay. Sometimes hay has been omitted, sweet potatoes being grown again after tomatoes, followed by tomatoes before seeding to clover and timothy.

In 1916 the sales from crops amounted to $8,392, and the income from livestock sales and milk $2,316, or a total income of $10,708. This is equal to an income of almost $84 per crop acre. The amount spent for labor was $2,220 and for other current expenses $4,752.

Cover Crops

For a number of years farmers have been urged by the Agricultural Experiment Station of New Jersey and by farmers' institute workers to plant cover crops to protect the soil from blowing and to turn these crops under as green manure. In some instances these suggestions have been followed with encouraging results. In Gloucester County the subject of cover crops has received but little attention until recently for the reason that city manure could be purchased at a reasonable price and produce crops at a profit. It was only occasionally that a farmer would plant rye or crimson clover. Since the war began, however, the cost of manure and fertilizers has been about twice what it formerly was and this has led these farmers to think more seriously of making use of some crop which could be turned under as a substitute for manure. In the fall of 1918 several fields of cover crops, particularly soybeans and rye and vetch, were found growing after corn or tomatoes. The soybeans had been planted in some cases with a narrow drill running between the rows of corn just after the last cultivation, planting at the rate of about a bushel of seed per acre, which had made excellent growth and would be turned under for the sweet potato crop.

Rye and vetch as a cover crop has been urged by the office of farm demonstration of Camden County, which adjoins this region on the north and the farmers have been enthusiastic over the results of demonstrations. In a few instances this crop has been grown in this region and the data obtained as the result of observation of the methods followed by farmers should encourage those who have been thinking along this line. From the standpoint of economical production of truck crops by those farmers growing cover crops, it is suggested (1) that no field be left bare over winter; (2) that soybeans, cowpeas, rye and vetch, or crimson clover be planted in corn at the last cultivation; (3) when the tomato field or other areas are not seeded to clover and timothy, rye and vetch or crimson clover should be seeded as early in the fall as possible, and if too late for legumes, such fields should be planted to rye; and (4) that the proper methods with respect to the amount of seed, the time and method of seeding, inoculation, and the use of lime should be strictly followed.[5]

Livestock

Table 10 gives the average number and distribution of livestock. The operators, only 2, of the 89 farms with less than 75 tillable acres, kept more than cows, while seven of the 36 having farms above that size kept 8 cows or more, averaging 13.5. One of the farmers with 16 cows made a practice of vealing calves and selling no market milk, but the income per cow on his farm was only 67 per cent of the average income per cow of the 6 farms from which the mil

[5] Farmers' Bulletins 550, 579. Crimson clover.
Farmers' Bulletins 515, 529, 967. Vetches.
Farmers' Bulletins 372, 931, 973. Soybeans.
Farmers' Bulletin 318. Cowpeas.
Farmers' Bulletin 924. A simple way to increase crop yields.
New Jersey Agricultural Experiment Station:
Bulletin 211. Sandy soils and their improvement in growing forage crops.
Circular 21. The soybean in New Jersey.
Circular 27. Cowpeas.
Circular 28. Crimson clover.
Circular 85. The value of cover crops.

was sold. The poultry industry is confined to farm flocks. Hogs are kept mostly to utilize the waste from the kitchen and to produce pork for family use. But 12 of the farms produced an average income from swine above $200, and one-half of these were large farms. The operator of one of the group of small farms sold young pigs amounting to $569.

Table 10

Distribution of Animals on 125 Farms in Gloucester County, New Jersey

Average of 3 Years, 1914-1916

	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75 acres and over	All farms	Productive animal units
Number of farms ..	26	33	30	36	125	125
Cows	1.2	2.0	2.8	5.5	3.0	
Young cattle	0.6	1.1	2.1	3.1	1.8	4.17
Bulls	0.1	0.0	0.2	0.5	0.2	
Work horses	2.5	3.7	4.9	5.8	4.3	....
Other horses and colts	....	....	....	....	....	0.08
Swine	2.6	3.4	4.8	5.0	0.0	0.87
Poultry	106.0	145.0	132.0	183.0	145.0	1.45
Total	....	....	....	....	....	6.58

Figure 10 shows graphically the percentage distribution of receipts given in table 11. It emphasizes the importance of crop enterprises in this region and shows the livestock industry to be a small factor in the success of the farm.

Receipts from Crops

Table 12 gives the percentage receipts from crops by groups, according to size of farm by tillable area. It also gives the average for the 125 farms. It will be noted that sweet potatoes and tomatoes are the most important crop enterprises from the standpoint of receipts, and that there is very little difference in the sales of each. Asparagus, white potatoes and cantaloupes are next in importance and the crop sales from all other sources are less than $100 each.

Farm Receipts

The average farm receipts in this area for three years as given in table 11 were: $3,620 in 1914; $3,992 in 1915; and $5,038 in 1916, or an average of

$4,217 for the 3-year period. The range was from $2,303 on the small farm to $6,042 on the large farm. The volume of business for the group of large farms, measured by the total receipts, was 2.6 times that on the small farms. The income from crops ranged from 83.5 to 85.0 per cent of the total income on the small and large farms, respectively, or an average of 86.3 per cent. The income from livestock ranged from 7.6 to 12.5 per cent, or an average of 10.5 per cent.

Table 11

Percentage Distribution of Receipts on 125 Farms in Gloucester County, New Jersey

Average of 3 Years, 1914-1916

	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75 acres and over	All farms
Number of farms	26	33	30	36	125
Total farm receipts	$2,303	$3,154	$4,853	$6,042	$4,217
	per cent	per cent	per cent	per cent	per cent
Crop receipts	83.5	87.7	88.2	85.0	86.3
Livestock receipts	12.1	9.9	7.6	12.5	10.6
Inventory increase of feeds and supplies	1.9	1.7	2.7	2.0	2.1
Miscellaneous receipts	2.5	0.7	1.5	0.5	1.0

The income from sweet potatoes varied but little from year to year but the amount of sales from tomatoes varied widely and in about the same proportion as the labor income. The income from this crop in 1915 with Group I was 61 per cent; with Group II, 68 per cent; with Group III, 64 per cent and with Group IV, 77 per cent of the 3-year average. It shows that the group of small farms was affected most and the group of large farms least by climatic or market conditions or was more efficient in tillage methods. In other words, it shows that sweet potatoes is a very dependable crop in this region and more so than tomatoes, although the latter crop may give a much larger income per acre. Farmers consider tomatoes a desirable and important crop because the income is received in mid-summer when it is needed for meeting expenses, while sweet potatoes are not sold until late summer and fall and often held in storage over winter.

Many of the smaller and more perishable truck crops were grown more extensively on the small farms. For example, there was over twice the percentage area of land in asparagus on farms having less than 35 tillable acres, and the smallest percentage area was found on large farms. Asparagus, cucumbers, lettuce, carrots, beets, lima beans, strawberries and similar crops are especially well suited to the small farmer doing a market-garden business. These crops, however, require a larger amount of hand labor. Some of them, of

Table 12

Percentage Receipts From Crop Sales by Size of Farms in Tillable Area, Gloucester County, New Jersey

Average of 3 Years, 1914-1916

CROPS	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75.1 acres and over	125 farms
	per cent	per cent	per cent	per cent	per cent
Corn	....	0.5	1.5	1.1	1.0
Small grain	0.1	0.2	....	0.3	0.2
Clover and timothy hay	0.3	0.8	0.8	1.7	1.1
Alfalfa hay	....	....	0.2	0.1	0.1
White potatoes	2.2	6.2	6.8	6.2	5.9
Sweet potatoes	26.6	36.0	29.1	35.9	33.0
Asparagus	18.6	8.3	9.3	5.6	8.6
Early tomatoes	28.2	31.3	33.8	33.6	32.6
Can-house tomatoes	2.8	3.7	3.4	2.9	3.2
Peppers	3.2	4.4	1.8	1.5	2.4
Eggplant	1.0	0.3	0.7	0.2	0.4
Cantaloupes	4.8	1.6	4.5	5.6	4.4
Watermelons	0.8	0.7	0.4	0.3	0.5
Small fruit	2.1	0.6	0.3	2.3	1.4
Peaches	2.4	1.5	6.5	0.6	2.6
Apples	0.4	0.6	0.2	0.7	0.5
Other truck crops	6.5	3.3	0.7	1.4	2.1

which turnips is an example, thus increase the intensity of the business. This crop is not confined to the small farmer, as not infrequently it is the practice on all farms to sow turnips in the clover and timothy seeding or as a catch crop after other truck crops to be sold or fed to livestock.

Table 13

Receipts from Tomatoes, Sweet Potatoes, Asparagus and White Potatoes for 1914, 1915 and 1916

Average of 125 Farms in Gloucester County, New Jersey

	Average per farm			Average per acre		
	1914	1915	1916	1914	1915	1916
Tomatoes	$1,196	$849	$1,863	$141	$98	$191
Sweet potatoes	1,237	1,173	1,188	104	131	104
Asparagus	266	324	355	175	196	202
White potatoes	228	166	250	77	57	100

Thirty-five per cent of the income from sweet potatoes, given in table 13, was from that portion of the crop sold in ⅝-bushel baskets, 40 per cent in bushel hampers, and 25 per cent in barrels. The small farmers sold half of the crop in baskets; on the other hand, a larger proportion of the crop on the large farms was sold in barrels.

Sixty-eight per cent of the income from early tomatoes was from that portion of the crop sold in 20-quart crates and 32 per cent in baskets. Eighty-four per cent of the tomatoes sent to canneries were sold in baskets and 16 per cent sold by the ton. There was very little difference in the way tomatoes were sold on farms of different sizes.

Livestock

Table 14 gives the average receipts per farm from livestock and its products. The income from milk was only 28 per cent of the income from eggs on the farms having less than 75 tillable acres, while the milk sales on the largest group of farms exceeded that from eggs by 36 per cent, three of these farms producing an average income from milk of $2,050.

Table 14

Sales from Livestock and Livestock Products by Size of Farm on 125 Farms in Gloucester County, New Jersey

Average of 3 Years, 1914-1916

ITEM	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75 acres and over	125 farms
Milk	$23	$32	$34	$282	$102
Eggs	57	56	44	59	54
Poultry	101	141	171	207	159
Other livestock	99	83	118	209	132

A considerable business is conducted in this region in dressed poultry, and the income from this source is about 11 per cent greater than that from eggs.

Table 15

The Relation of Price Index to Size of Farm in Gloucester County, New Jersey

YEAR	35 acres and less tillable	35.1 to 55 acres tillable	55.1 to 75 acres tillable	75 acres and over tillable	All farms
1914	96	98	95	96	96.4
1915	94	96	95	100	96.7
1916	92	97	100	103	98.4
Average	94	97	97	99	97.0

The prices received from farm products, considering the farm as a whole, or the price index, is an important factor in farm profits. Table 15 gives the price index for the period studied. The figures represent in percentages the average price received for all products sold in any one group of farms with the average of all farms. For example, in the group of small farms the price index is 96 for the year 1914. It means that the average price received for 100 acres of crops on those farms was equivalent to 96 acres of crops on the average farms in the region. In other words, the prices received for products on the small farms was 4 per cent below the average. These figures should be used only relatively, as theoretically the 3-year average should be 100 but is 97 because several crops which were grown only on a few farms were left out of the computation.

Table 16

Distribution of Expenses by Size of Farm in Tillable Area and for the 125 Farms in Gloucester County, New Jersey

Average of 3 Years, 1914-1916

	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75 acres and over	125 farms	
					Dollars	Per cent of Total Expense
Paid labor	$317	$441	$789	$1,122	$695	25.9
Unpaid family labor	112	174	153	172	156	5.8
Board of labor	47	62	107	134	90	3.4
Total labor	476	677	1,049	1,428	941	35.1
Repairs:						
Buildings and fences	38	50	59	85	60	2.3
Machinery and hot-beds	21	26	44	66	41	1.5
Feeds:						
Hay	33	35	48	34	37	1.4
Grain	196	164	209	255	207	7.7
Seeds	29	49	78	86	63	2.3
Manure	171	260	337	392	298	11.1
Fertilizer	164	275	443	538	368	13.7
Lime	12	18	24	37	24	.9
Spray material	9	16	32	38	25	.9
Horse shoeing	14	24	29	38	27	1.0
Baskets, crates, etc.	84	162	348	335	240	9.0
Insurance	13	18	31	32	24	.9
Taxes	58	78	120	141	102	3.8
Other current expenses	39	38	44	63	47	1.8
Depreciation:						
Buildings and fences	49	59	75	85	68	2.5
Machinery and hot-beds	60	74	109	113	91	3.4
Decrease feed and supplies	16	15	12	29	19	.7
Total farm expenses	$1,482	$2,038	$3,091	$3,796	$2,682	100.0

Farm Expenses

Table 16 gives the distribution of the principal farm expenses. The largest items are for labor, feed, manure, fertilizer and containers. The expenses for paid labor in 1916 were 21 per cent greater than in 1914 and 24 per cent greater than in 1915. This expense is divided into regular and extra labor, the regular help being month hands for the season or for the year, while the extra labor is that required chiefly for picking tomatoes, sweet potatoes and harvesting other truck crops, much of which is contracted and paid on the

unit basis. This extra labor was a little more than 43 per cent of the total paid labor cost and the greater cost in 1916 was principally for this kind of help in harvesting the larger crops. The amount of family labor does not vary much on farms of different sizes, but the percentage cost on the large farms is less than two-thirds that on the small farms. The value of the labor furnished by the family was one-sixth of the total labor cost. The total cost of labor was 35.1 per cent of the total farm expense.

More hay was purchased by the small farmers though the amount purchased was relatively small for a trucking region. The most successful large farmers find it pays to produce all the hay and as much corn as possible to cut down the grain bill. Corn stover generally supplements hay and is a very good feed when carefully cured. The farmer with a limited crop area finds it does not pay to put more land into hay crops except alfalfa. The per cent of the total farm expenses for feed is relatively about the same as in some general farm regions studied, but is about one-half of the cost of feed in good dairy regions.

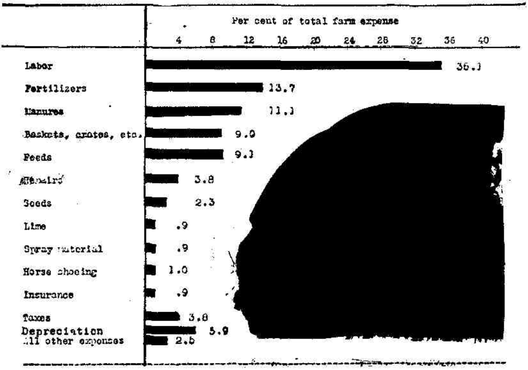


FIG. 11. PERCENTAGE DISTRIBUTION OF FARM EXPENSES ON 125 FARMS IN GLOUCESTER COUNTY.

The per cent of the total farm expenses for manure did not vary over 1 per cent in the different groups of farms arranged by size, nor did it vary much in the years this study included. The cost of commercial fertilizers on farms having more than 55 tillable acres was 4 per cent more than on the smaller farms. This may be due to the fact that the operators of these farms had more ready capital. Lime is not used extensively in this area, as less than $25 was spent for this material.

The cost of baskets, crates and barrels on these farms averaged $240, or 9.0 per cent of the total farm expense. With the smallest group of farms this cost was 3.4 per cent less than the average for the 3-year period. It indicates that the operators of the large farms purchase more new material in the form of crates and barrels, while those of small farms utilize material on hand and ship their produce principally in ⅝-bushel baskets.

The average depreciation on buildings, fences and machinery was $159 per farm, or 5.9 per cent of the total expenses. Of this amount $68, or 2.5 per cent, was on buildings and $91, or 3.4 per cent, on machinery and hot-beds. The total depreciation was 7.3 and 5.2 per cent respectively, on small and

large farms, the difference being due to the larger proportion of capital in buildings and machinery on the small farms. The average expense for repairs on buildings, machinery and hot-beds was $101, or 4 per cent of the total farm expense. This makes the total cost of repairs and depreciation $260, or 9.9 per cent of the total expenses.

Table 17

Relation of Size of Farm to Distribution of Capital on 125 Farms in Gloucester County, New Jersey

	Farms Grouped According to Tillable Area				
	35 acres and less	35.1 to 55 acres	55.1 to 75 acres	75.1 acres and over	Total
Number or farms	26	33	30	36	125
Number of acres in crops	24.6	41.0	57.9	81.4	53.3
Total capital per farm	$5,844	$7.986	$11.768	$14,920	$10,445
Percentage of total capital in:					
Land	39.4	41.8	45.8	44.6	43.8
Dwelling	21.0	19.4	14.8	14.0	16.1
Tenant houses	....	0.7	2.3	2.0	1.6
Other buildings	14.4	13.7	13.3	13.8	13.7
Total real estate	74.8	75.6	76.2	74.4	75.2
Work stock	6.0	6.5	6.4	6.7	6.5
Other livestock	3.7	3.6	3.4	5.4	4.3
Machinery	9.2	8.0	8.3	7.6	8.1
Feed and supplies	2.6	3.2	2.8	3.3	3.0
Cash	3.7	3.1	2.9	2.6	2.9
Total working capital	25.2	24.4	23.8	25.6	24.8

The average value of the operator's labor on these farms was $480. This figure is not included in farm expenses, but is part of the labor income, which is what the operator receives for his labor and supervision. It represents but little more than actual labor on the farm and is about what the owner would have to pay for a good hired man.

Investment

The farm investment consists of real estate and working capital. The real estate is separated into land, dwelling and other buildings and the working capital into livestock, machinery, feed and supplies and cash for operating the farm business. The average total investment for the 3-year period on the

125 farms was $10,445, or $5,844 on the small farms increasing to $14,920 on the large farms. The average real estate investment was $7,850 per farm, or 75.2 per cent of the total capital. The working capital was $2,595 per farm, or one-fourth of the farm investment.

The percentage distribution of the farm investment in this area from 1914 to 1916, inclusive, together with the 3-year average, is shown in table 17.

The average value of the land, exclusive of buildings, was $4,575, or 58 per cent of the value of real estate. The average value of real estate per acre was $97 and varied from $89 on the large farms to $122 on the small farms. The average value of land per acre exclusive of buildings was $57. The average increase in the value of real estate during the 3 years was $2 per acre, or an increase of 2.1 per cent. Fifty per cent of this increase was for improvements on dwelling and other buildings.

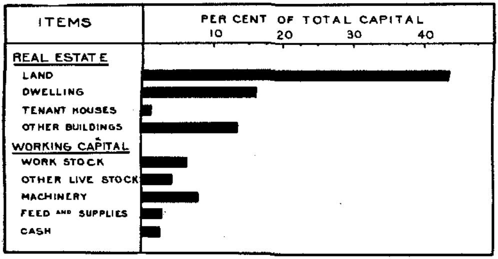


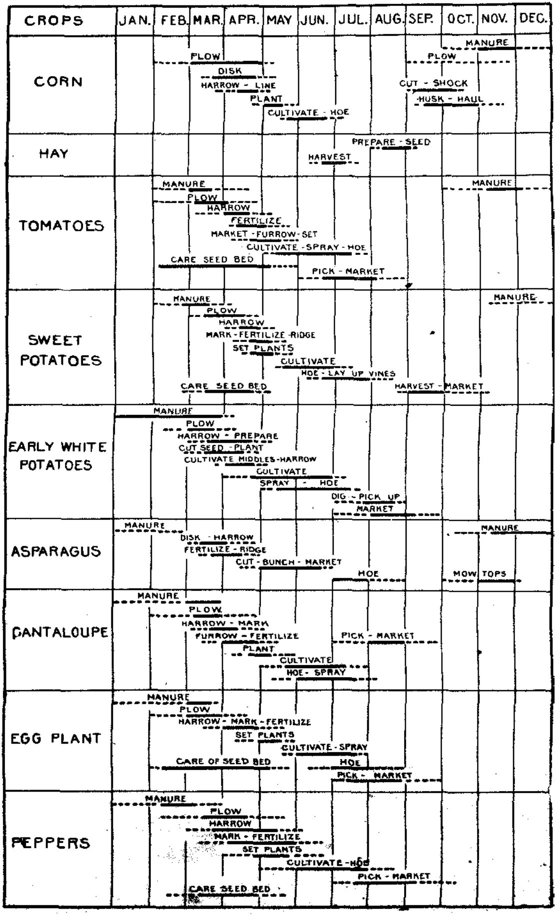
FIG. 12. DIAGRAM SHOWING PERCENTAGE DISTRIBUTION OF FARM INVESTMENT.

The investment in machinery was $845; work stock, $679; other livestock, $449; feed and supplies, $313, and cash to operate the farm, $303.

Seasonal Distribution of Labor

The number of farms in this area in which there is an attempt to follow a definite cropping system is extremely small. Even those farmers who do have in mind such a system as an ideal which they try to follow are frequently not able to do so. The market demands, the scarcity of help, the competition of crops for labor, climatic changes and the prices offered for farm products all have an influence on the arrangement of the cropping system and the farmer may find it necessary to change his plan quite materially from the ideal which he had in mind. This is especially true with this type of farming.

When such changes have to be made it is essential that the farmer know the time of performing different operations and the limit of time in which planting may be done in order to be assured of profitable returns. As a rule, farmers know this and figure carefully on the labor requirements and make plans for the cropping system on the basis of labor supply. When extra help can be obtained easily for harvesting and shipping tomatoes and other crops which require considerable extra labor, this problem is not serious. Fortunately, the crops which bring the largest returns do not compete seriously in labor requirements. In order to give assistance in adjusting the cropping system to give a more uniform distribution of labor, the time of preparation of ground, planting, cultivation and harvesting the most important farm crops in this area are shown in figure 13. The average dates when the different operations are performed by the majority of farmers are presented by the heavy


CROPS
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
CORN
MANURE
PLOW
PLOW
DISK
HARROW - LINE
CUT - SHOCK
PLANT
HUSK - HAUL
CULTIVATE - HOE
HAY
PREPARE - SEED
HARVEST
TOMATOES
MANURE
MANURE
PLOW
HARROW
FERTILIZE
MARKET - FURROW - SET
CULTIVATE - SPRAY - HOE
CARE SEED BED
PICK - MARKET
SWEET POTATOES
MANURE
MANURE
PLOW
HARROW
MARK - FERTILIZE - RIDGE
SET PLANTS
CULTIVATE
HOE - LAY UP VINES
CARE SEED BED
HARVEST - MARKET
EARLY WHITE POTATOES
MANURE
PLOW
HARROW - PREPARE
CUT SEED - PLANT
CULTIVATE MIDDLES-HARROW
CULTIVATE
SPRAY - HOE
DIG - PICK UP
MARKET
ASPARAGUS
MANURE
MANURE
DISK - HARROW
FERTILIZE - RIDGE
CUT - BUNCH - MARKET
HOE
MOW TOPS
CANTALOUPE
MANURE
PLOW
HARROW - MARK
FURROW - FERTILIZE
PICK - MARKET
PLANT
CULTIVATE
HOE - SPRAY
EGG PLANT
MANURE
PLOW
HARROW - MARK - FERTILIZE
SET PLANTS
CULTIVATE - SPRAY
CARE OF SEED BED
HOE
PICK - MARKET
PEPPERS
MANURE
PLOW
HARROW
MARK - FERTILIZE
SET PLANTS
CULTIVATE - HOE
PICK - MARKET
CARE SEED BED

It will be noticed that some crops compete seriously in the man labor required for certain operations. For example, asparagus will require continuous attention in cutting and preparing for market in May and the larger part of June, and at the same time the setting of early tomatoes, sweet potatoes, eggplant or peppers must be completed and cultivation of all these crops continued during this season. It is probably for this reason that farmers growing these crops extensively put only a small area in asparagus, and those that make asparagus the principal farm crop will grow a greater acreage in white potatoes, corn or hay. The farmer brought up in this type of farming has learned from experience in growing these crops to plan the cropping system, but to one unfamiliar with the time for performing these operations and the amount of labor required for each, such a chart will be of great assistance in planning the distribution of the crop area.

Table 18

Hours of Labor for Preparation of Ground, Cultivation and Care of Crop, Harvesting and Marketing for the Principal Farm Crops in Gloucester County, New Jersey

	Corn		Hay*		Tomatoes		Sweet Potatoes	
Operation	Man Hours	Horse Hours	Man Hours	Horse Hours	Man Hours	Horse Hours	Man Hours	Horse Hours
Preparation of ground and planting	17.3	28.4	8.4	17.8	88.0	60.2	71.4	55.1
Cultivation and care of crop.	14.5	14.2	.....	.....	22.4	19.2	43.3	14.7
Harvesting and marketing...	37.4	11.7	12.4	10.6	109.2	62.3	66.0	51.9
Total labor	69.2	54.3	20.8	28.4	219.6	141.7	180.7	121.7

	White Potatoes		Asparagus *(bearing)*		Canta-*loupes*		*Peppers*	
Preparation of ground and *planting*	33.7	40.0	.....	.....	28.0	33.0	81.0	46.5
Cultivation and care of crop.	18.2	20.7	18.2	25.5	33.5	13.5	42.1	27.9
Harvesting and marketing..	47.4	42.8	173.0	25.0	76.5	37.5	101.5	68.2
Total labor	99.3	103.5	191.2	50.5	138.0	84.0	224.6	142.6

* If hay is cut 2 years the average total amount of labor will be found by multiplying the hours of labor for harvesting by 2, adding the hours for seeding, then taking one-half the sum.

In connection with the use of figure 13, table 18 is necessary in estimating the amount of labor for carrying out the farm plan. The figures given in this table are averages of a large number of records of the most prominent crops grown in the region. In order to simplify the use of the table, the farm operations are grouped into three general divisions, namely, preparation of ground and planting; cultivation and care of crops; and harvesting and marketing. As a rule, the regular farm labor will handle the work during the first two periods, but extra labor is necessary for harvesting. It is important to

know whether the farm help will get the crops planted at the proper time. No matter how carefully the work for the season may be planned, conditions may arise, such as a late spring or an excessive wet spell, that hinders the farm work. The question often in the farmer's mind is whether the acreage planned can be put in before it is too late or should a part of the land prepared for some particular crop be planted to some other crop. At such a time these figures and this chart will also be useful for making the proper adjustment.

Relation of the Size of Farm to Labor Income

Table 19 shows the relation of the size of farm to labor income on these farms for three consecutive years, and the average for the 3-year period. It also shows how the net profits vary from year to year with the type of farming.

Table 19

Relation of Size of Farm to Labor Income on 125 Farms in Gloucester County, New Jersey

Size of Farms In Tillable Acres	Number of Farms	Average Number of Tillable Acres	Average Labor Income				Per cent of farms with labor income of 1,000 or more
			1914	1915	1916	3-year period	
Under 35	26	26.1	462	278	848	529	18
35.1 to 55	33	45.7	606	377	1,167	717	34
55.1 to 75	30	65.0	964	430	2,126	1,173	48
Over 75	36	97.7	1,445	634	2,422	1,501	60
Average	125	61.2	904	443	1,692	1,013	42

On dairy farms having less than 35 acres of tillable land, averaging 26.1, the labor income amounts to no more than a hired man's wages and much less than wages in 1915. This labor income represents what the farmer receives *for his labor and managerial ability. The group of farms averaging 45.7* tillable acres received an average labor income of $717, or an income of over 35 per cent greater than that of the small group of farms. The next larger group of farms averaging 65 acres, made a labor income of $1,173, or 63 per cent greater than the second group. The farms of over 75 acres, averaging 97.7 acres, produced a labor income of $1,501, or 28 per cent more than the third group of farms. These increases are nearly in direct proportion to the size of farm and show that the farms having from 55 to 75 acres of tillable land seem to be more efficiently managed. Undoubtedly these farms have a distribution of crop area that keep regular men continuously employed, utilize harvest labor to better advantage, and are able to use larger machinery with greater efficiency.

This table also shows the influence of weather and marketing conditions on the labor income, and how the net amount that the farmer receives may vary greatly. The farmer may prepare his plans for a cropping system very carefully, prepare the land for crops thoroughly and apply manures and fertilizers with the expectation of profitable crops, and adverse conditions may bring the results expressed for 1915 in the above table. If the farmer can expect to get the returns of 1916 one year in three, it shows that this type of farming in this region is profitable, but *that a certain amount of cash capital must be reserved to tide over the poor year* and provide for the purpose of supplies for the succeeding year.

Figure 14 shows graphically the relation of the size of farm to labor income. The vertical lines divide the 125 farms into four groups by tillable area and the horizontal lines give the scale for the labor income received. The dotted line representing the labor income for the year 1915 has very little curve and shows, moreover, but slight increase in income from the larger farms. The line income for 1914 rises much more sharply with farms above 45 acres in tillable land and the rate of increase then is directly proportional to the area. The line of income for 1916 begins at $848, which is three times that of 1915, and rises moderately, and the income increases 37.6 per cent on farms having 45.7 tillable acres. The *line rises sharply for groups above 45 acres*, and the labor income increases 82.2 per cent on farms having 65 acres. Above farms of this size, the line drops back and the rate of increase is less on the larger farms. The heavy line shows the average for the 3-year period. It appears evident from this chart that the more efficiently managed farms of the area during this period were farms having from 45 to 65 acres of crop land.

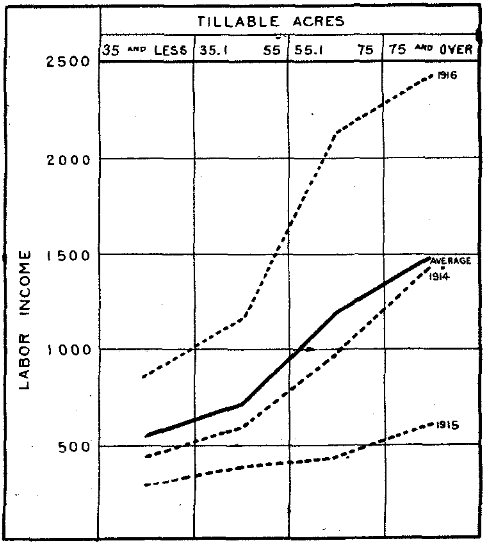


FIG. 14. DIAGRAM SHOWING RELATION OF SIZE OF FARM TO LABOR INCOME.

Relation of the Size of Farm to Efficient Use of Labor and Capital

In table 20 some of the reasons are given why it is easier to make a more satisfactory income on a large farm than on a small one. *On most farms a great deal of time is devoted to work which adds little or nothing to the profit*

of the business. Studies of other types of farming, such as general farming with dairying, emphasize this more strikingly. In this region the small truck farms utilized profitably but 59 per cent of the total labor employed, while the larger farms, averaging 58 crop acres, utilized 78 per cent of the total labor in productive work. A productive work unit is an average day's work for man or horse applied to those enterprises which are sources of income to the farm.

Table 20

Relation of the Size of Farm to Efficient Use of Labor and Capital (125 farms)

Size of farm in tillable area	Number of Farms	Productive work units per farm		Crop-Acres per Man	Crop-Acres per Horse	Cost of Total Labor per Crop-Acre	Months of Labor		Value of Machinery per Crop-Acre
		Man	Horse				Per Farm	Per Crop-Acre	
35 acres and less ..	26	374	231	12.10	10.50	$19.35	25.4	1.03	$21.78
35.1 to 55 acres ..	33	537	369	16.99	11.51	16.51	30.4	0.74	15.55
55.1 to 75 acres ..	30	760	519	18.71	12.23	18.12	39.1	0.69	17.16
75 acres and over ..	36	959	671	20.97	14.28	17.54	48.4.	0.59	13.88
Average	125	657	448	17.53	12.27	$17.72	36.77	0.68	$16.09

Great efficiency in the use of labor also is shown by the number of crop-acres per man or horse. On the small farms, 12.1 acres of crops were taken care of per man and 10.5 acres per horse, while on the larger farms, 20.97 and 14.28 crop-acres were handled, respectively, per man and per horse. This means that man labor was 73 per cent and horse labor 36 per cent more efficient on the largest farms. The number of months of employed labor on the farm apportioned per acre of crops shows even greater efficiency on large farms. Each crop-acre on the small farms required 1.03 months of man labor, but only 0.59 month of labor per crop-acre on the large farms.

In the use of capital, the cost of hired labor per crop-acre was $19.35 on the small farms and $17.54 on the large farms. This decrease in the cost of labor is not directly proportional to the size of farm, but the highest cost of the small farms was probably influenced by the greater proportion of acres in crops that required a larger amount of harvest help, particularly the labor required on such truck crops as beets, carrots, onions, etc.

The value of tools and machinery per crop-acre generally decreased with the size of the farm. Operators of the group farms, however, having between 55 and 75 acres of tillable land expended more for machinery than those of the groups of farms with 35 to 55 acres. In other words, operators of the smaller farms seemed to find it necessary to have as much equipment as would be required on the large farms.

The amount of man or horse labor required in this area per crop-acre is much larger than that required in many other agricultural regions, on account of the type of farming and the labor required for harvesting, packing and delivering truck crops to market or the shipping point. Much of the preparation and cultivation is done by small machinery. If larger farm tools, such as riding cultivators, 4-horse outfits for plowing and harrowing, or a tractor outfit on the larger farms could be used, the efficiency in the use of labor and machinery would be increased and the cost of growing crops reduced. Since this study was made some tractors and many trucks are being used on farms from which a large quantity of produce is shipped.

Table 21

Relation of Months of Labor Employed to Labor Income and the Efficient Use of Labor

Months of Labor	Number of Farms	Months of Labor	Crop-Acres	Crop-Acres per man	Crop-Acres per horse	Labor Expense	Labor Income
26 and less	29	21.8	30.4	16.7	10.7	$370	$603
26.1 to 35	41	31.0	45.7	17.7	11.6	715	717
35.1 to 45	30	39.6	61.6	18.5	13.1	999	1,181
45 and over	25	59.9	85.3	17.1	14.1	1.884	1,758
Average	125	36.8	53.3	17.5	12.3	$1.030	$1.013

Table 22

Relation of Crop Index to Expense of Labor, Manure, Fertilizer and Labor Income

Crop Index	Number of Farms	Crop Index	Crop-Acres	Labor Expense per Acre	Manure Expense per Acre	Fertilizer Expense per Acre	Labor Income
90 and less	44	77	51.7	$15.20	$5.22	$6.38	$528
91 to 110	44	99	54.1	16.72	5.47	6.95	961
110 and over	37	129	55.2	21.20	6.41	8.77	1,655
Average	125	100	53.3	$17.65	$5.60	$7.36	$1,013

Relation of Yield per Acre of Crops Grown to Labor Income

The quality of farming can be measured by the yield per acre. The measure adopted in such studies is what is known as the crop index, which is the average yield on any particular farm compared with the average yield of the farms

studied in the community expressed in percentages. For example, if the cr index on one farm is 90, it means that 90 acres of crops having an avera yield of all farms studied would produce the same as 100 acres of crops c this farm. In other words, the crops on this farm were but 90 per cent a great as on the average farm.

The 125 farm records were arranged in three groups according to crop yield The crop index of the first group was 77, of the second group 99, which wa practically the same as the average of all records, and of the third group 12 The average labor income increased in about the same ratio, and the 3 farms having crop yields 29 per cent above the average produced an average c $1,127 more labor income than the 44 farms having crop yields 23 per cen less than the average of all farms. It shows that a good yield per acre is a important factor in profitable farming. There was but little difference in th acres of crops grown and in the expense per acre of manure and fertilizers.

Relation of Price Index to Crop Yields, Labor Income and Per Cent o the Investment

The price index is a measure of the prices received for farm products. I is determined in a similar manner as crop index, comparing the average pric for crops sold on each farm with the average price received by all farms as 10 per cent. The records were arranged in three groups, 41 farms having a pric index of 87 or less, 46 farms with an index between 88 and 103, and 36 farm with an index of 104 or over.

Table 23

Relation of Price Index to Crop Yields, Labor Income and Pe Cent on Investment

Average of 3 Years, 1914-1916, on 125 Farms

Price Index	Number of Farms	Crop-Acres	Price Index	Crop Index	Labor Income	Per Cent on Investment
87 and less	41	49.8	76	104	$630	7.1
88 to 103	46	52.9	96	100	855	9.0
104 and over	38	57.5	119	97	1,604	14.1
Average	125	53.3	97	100	$1,013	10.0

It will be noticed in table 23 that the farmers receiving the lowest prices for their crops, an average price index of 76, had crop yields above the average in the region, and that the farmers receiving high prices, an average price index of 119, had crop yields slightly below the average. The average labor income, however, increases with the prices received, showing that the prices

offered for their products is just as important a factor in profitable farming as the yield per acre. The aim should be, therefore, not only to have crop yields above the average, but to obtain prices for the crops above the average as well. The farm practice in growing and marketing farm crops and the business ability in disposing of the produce will strongly influence these factors which affect profits.

The Use of Manures and Fertilizers in their Relation to Crop Yields and Labor Income

The amount spent for manures and fertilizers in this area is about one-fourth of the total farm expenses. For years the farmers have depended upon city manure to supply organic matter to these sandy soils, supplementing the plant-food furnished in the manure by the use of commercial fertilizers. As long as farming is profitable this system is justified, but when the price of manure is increased above the point of profitable returns, other methods will be adopted. Already the acreage of cover crops is being increased, such as rye, cowpeas, soybeans or crimson clover to be turned under for green manure, which will reduce the need for purchased manure.

Table 24

Relation of Manures Purchased to Crop Yields and Labor Income

Average of 3 Years, 1914-1916

	Number of Farms	Cost of Manures per Farm	Cost of Fertilizers per Farm	Cost of Manures Applied per Crop-Acres	Crop-Acres	Crop Index	Labor Income
Per Farm—							
$250 and less	64	$144	$290	$3.37	42.7	96	$742
Over $250	61	458	498	8.02	62.0	105	1,295
Average	125	$298	$392	$5.27	53.3	100	$1,013
Per Crop Acre:							
$6 and less	69	......	......	3.60	57.9	97	1,026
Over $6	56	......	......	9.01	47.6	103	1,004

In order to throw some light on these problems the records were sorted according to the amount of these materials purchased and studied with a view of finding the relation of the amount spent for manures and fertilizers to the net farm income. Table 24 shows the relation of cost to crop yields and labor income by sorting the 125 records into two groups, under or above $250 spent per farm for manure. It also shows the same relation when the records were sorted under or above $6 per acre. In the first case the result in labor income may be misleading, as it includes the factor of size of farm indicated by the

crop area. In the second part of the table the size factor has been eliminated and the result shows the labor income to be $22 less and the crop yields 6 per cent greater on those farms where over $6 per acre is spent for manure. The results indicate that during the 3 years, 1914 to 1916, the price of manure could not be increased with profit unless the prices received for farm products also were increased, or unless the factors affecting profits were adjusted.

Table 25

Relation of Fertilizers Purchased to Crop Yields and Labor Income

	No. of Farms	Cost of Fertilizers per farm	Cost of Manures per farm	Cost of Fertilizers Applied per Crop-Acre	Crop-Acres	Crop Index	Labor Income
Per Farm—							
$300 and less	61	178	194	$5.35	33.3	89	$551
Over $300	64	598	398	8.24	72.6	111	1,459
Average	125	392	298	$7.36	53.3	100	$1.013
Per Crop Acre—							
$12 and less	63	...	...	9.09	56.6	96	983
Over $12	62	...	...	17.46	49.9	105	1,135

Table 25 shows the relation of commercial fertilizers purchased per farm and per crop-acre for the 3-year period. The operators of the 64 farms purchasing fertilizer amounting to $300 or more per farm spent three times as much for fertilizers and twice as much for manure as the operators of 61 farms purchasing less than $300 per farm. The average farm in the group on which more was spent for fertilizers had more than twice the crop area. The crop yields in this group were increased 22 per cent and the labor income $900. When the factor of size of farm was eliminated by sorting the records according to the amount spent per crop-acre, the labor income was increased $242.

Value of What the Farm Furnishes Towards the Family Living

In 1913, the year previous to the first year of the survey, a study was made in this area to determine what the farm furnished toward the family living in vegetables, meat, dairy and poultry products, fruit, fuel and the value of house rent. The value of these is not included in the farm receipts of the 3-year survey, because these were not cash transactions. Nevertheless, the value of what is furnished by the farm toward the support of the family should be considered in connection with the net farm income, in order to make the results more comparable with the kinds of business where such things are not furnished.

Table 26

Value of What the Farm Furnishes Towards the Family Living for 1913 in Gloucester County, New Jersey (118 Farms)

Size of Farm	No. of Farms	No. in Family	Acres in Farm	House Rent	Wood	Meat, Dairy and Poultry Products	Fruit	Vegetables	Value of Total Food Furnished	Value of Food Consumed
15 to 40 acres .	30	3.8	27.8	$122	$8.52	$121.29	$14.82	$49.06	$185.17	$467.51
41 to 65 acres .	28	4.4	53.6	154	14.56	171.80	17.53	67.28	256.61	511.29
66 to 90 acres .	22	4.7	79.4	169	17.22	187.76	24.70	73.12	285.57	571.86
91 acres and over	38	5.9	118.6	197	18.43	247.06	20.14	88.04	353.67	719.38
Average	118	4.8	72.8	$162	$14.77	$186.17	$19.02	$70.42	$275.61	$578.47

Table 26 gives the value of house rent, fuel and food, including meat, fruit and vegetables, furnished the family from the farm. It also includes the value of the total food consumed. One hundred and eighteen records were arranged by size of farm averaging 27.8, 53.6, 79.4 and 118.6 acres, respectfully, for the four groups. The number of persons in the family varied from an average of 3.8 on the small farms to 5.9 persons on the largest farms.

The value of food consumed on all farms averaged $578.47, of which $275.61, or 47.5 per cent, was furnished from the farm. Including the value of house rent and fuel, the farm furnished $452.38 toward the family living, an amount which would have been spent by the family in any other business than farming where everything was purchased. The value of the total food consumed by the family, wood furnished by the farm, and house rent, amounted to $755.24 for an average family of 4.8 persons, or a value of $157.33 per person. The proportion of this amount furnished by the farm per person was 59.9 per cent, or $94.24. The farm furnished 67 per cent of the total food consumed in dairy and poultry products, 7 per cent in fruit and 26 per cent in vegetables.

These figures vary somewhat on farms of different sizes. The farms averaging 27.8 acres furnished food products per person to the value of $48.73; the next group of farms larger in size, averaging 53.6 acres furnished a value of $58.32 per person; while the 60 farms above 66 acres in size furnished food products valued at $60.23 per person. It would appear that on the small farms with smaller acreages of truck crops and therefore smaller incomes, a smaller proportion of food products was reserved for family use.

REPORT OF THE DEPARTMENT OF BIOLOGY

Department of Biology

Thurlow C. Nelson, Ph.D., Biologist

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Report of the Department of Biology

THURLOW C. NELSON

I. INTRODUCTION

No report has been made from this department for the past three years on account of the absence of the assistant biologist in war service. Two weeks were spent in June, 1917, at the laboratory at Edge Cove, Tuckerton, followed by the enlistment of the investigator. From this time nntil March, 1919, no investigations were carried on at the oyster culture laboratory.

Upon the writer's release from service, early in 1919, a request was made of the United States Bureau of Fisheries for financial cooperation to aid in starting anew the work of the New Jersey station. The ready and generous response of the bureau in providing for four months' salary of the investigator made it possible to begin observations at Edge Cove on March 1, four months earlier than would otherwise have been the case.

Investigations at the floating laboratory were carried on continuously from March to September, the longest period of uninterrupted observations made at this station since the beginning of the work in 1888 by Dr. Julius Nelson.

It is a pleasure at this time for the writer to express his appreciation in behalf of the Experiment Station for this most timely support and cooperation of the United States Bureau of Fisheries.

II. INVESTIGATIONS IN 1917

Two weeks of June, 1917, were spent in conducting plankton surveys of Edge Cove and parts of Little Egg Harbor. The first examination, made on June 12, showed 517 small oyster larvæ per 100 quarts of water, density 1016, temperature 73°F. These larvæ grew rapidly, and by June 22, when the last examination was made, were nearly ready to set. The water on this date had a density of 1619, temperature 76°F.

On June 26 a brief survey was made of the waters of upper Barnegat Bay, from the mouth of Cedar Creek northward to Barnegat Pier. Great numbers of oyster larvæ and those of the hard clam were found

in water of a density of 1004, temperature 76°F. Many of the oyster larvæ were within a few days of the setting stage. The density of the water, 1004, is well below that at which the adult oyster ceases to feed, and yet these larvæ were swimming actively about and feeding continuously. Plans were made at the time to undertake more extensive surveys, with a view of determining the distribution of the oyster larvæ in the fresher waters at the mouths of streams.

The work of the station being discontinued at this time, a portion of the unspent appropriation was used in the purchase of an 11-H. P. 2-cylinder marine motor for installation in the station launch *Novia*. This gives the launch sufficient power to tow the floating laboratory and also increases her speed and general usefulness in survey work.

During the very severe winter of 1917-18, the floating laboratory *Cynthia* was sunk at her moorings in Tuckerton Creek. A former laboratory assistant of the station, Prof. P. C. Cameron, went to Tuckerton, and about six weeks later the boat was raised. Great credit is due Capt. Frank V. Frazier and Capt. Walter Gale for their skill in salvaging the boat. Damage amounting to about fifty dollars was sustained by the contents of the laboratory. The boat itself, save for the loss of the samson post, was unharmed.

III. INVESTIGATIONS IN 1919-20

As explained in the introduction, no observations were made from June, 1917, until March, 1919, when the station was reopened at Edge Cove with the aid of the United States Bureau of Fisheries. The investigations begun at this time were so planned as to make the best possible use of the extended period of observation and fall under the following heads:

(A) Studies of the rate of growth of adult oysters.
(B) Analysis of stomach contents of adult oysters to determine types of food eaten.
(C) Observation of the feeding habits of oysters as affected by environmental factors.
(D) Further studies of the duration of the larval period, and the conditions governing the setting period.

(A) Studies of the Rate of Growth of Adult Oysters

As the first step in determining the food requirements of oysters it is necessary to have accurate data covering the rate of growth over a given period, together with all possible information as to the water conditions, i. e., density, temperature, turbidity, food content and speed of currents.

Two lots of oysters were used in determining the rate of growth. Lot 1 consisted of Edge Cove and Huey's Creek naturals from 2 to 6

years old. Lot 2 was of oysters which set in Grassy Channel, Great Bay, in the summer of 1916; were removed to beds in Great Bay the following spring, and brought to the laboratory at Edge Cove on March 30, 1919.

One thousand oysters were used in this experiment, 150 of lot 1 and 850 of lot 2. The shells of the oysters were scraped thoroughly and scrubbed with a brush to remove all adhering growths, barnacles, hydroids, sponges, etc. With a fine dentist's drill a small hole was then bored through the tip of the left valve in front of the ligament, and a small numbered copper tag wired fast. The position of the wire and tag was such that the shell movements of the oyster were in no way interfered with, nor was there any possibility of irritation on the part of the oyster. Only such oysters were used in which the edges of the valves were intact and tightly closed, insuring the absence of any air between the shells. In no case were the oysters kept out of the water longer than 12 hours.

After tagging each oyster it was weighed and its length and width measured. Lots of 50 at a time were then planted in Huey's Creek, in front of the floating laboratory, on platforms specially designed for this purpose. These platforms were built with rectangular frames of 2 by 4-inch timbers to which was fastened a bottom grating of shingling lath 2 inches wide, with 1 inch between each two laths. The platforms were fastened securely to the bottom on a level with the surface of the water at low tide.

The experimental oysters were set in rows, on end, hinge downward in the cracks of the grating. The entire shell margin was thus left free to grow, besides permitting a maximum of oysters in a given space. The entire 1,000 oysters occupied only about 15 square feet. Planting was begun on April first and ended on the twenty-eighth.

The writer is indebted to George A. Mott, director of the New Jersey Board of Shell Fisheries, and a life-long friend, for the suggestion of using platforms for this work. Without some such means of holding the oysters above the soft mud bottom uniform results could not possibly have been obtained.

In order to make a comparative study of the rate of growth on the platform and on the bottom, two trays, 2 by 1½ feet, were made of ½-inch galvanized wire. Oysters 801 to 900 were set in one of these trays on the platform, and oysters 901 to 1,000 were put in the other on the bottom of the creek directly beneath the tray on the platform.

The currents, with the ebb and flow of the tide, took a diagonal course across the platform. The average speed of these currents was 26 feet per minute, or, roughly, 0.3 mile per hour.

The oysters were removed in August, cleaned, weighed and measured as before. They were then taken to Elder Creek, Great Bay, for the winter.

Tables 1 and 2 show in summary the results of this experiment.

The following important results are shown in table 1: First, Huey's Creek Naturals, which, except for their position on the platform, were under conditions identical with those of their previons existence, showed an increase in 133 days of 21 per cent in weight. The Grassy Channel stock, brought from Great Bay, where they had been nnder somewhat different, though entirely favorable, conditions, increased over 31 per cent in a growth period 10 days shorter. This finding is in accord with the experience of many practical oyster growers that transplanted seed will often far out-grow the native stock.

Table 1

Growth of Oysters

OYSTERS	Number Counted	Period	ORIGINAL Weight	ORIGINAL Length	ORIGINAL Width	CHANGE Weight	CHANGE Length	CHANGE Width
		days	gm.	cm.	cm.	gm.	cm.	cm.
Naturals, 150	126	133	13,862	1,173.9	827.2	2,904	222.1	126.7
Average	1	133	110	913.0	6.6	23	1.8	1.0
Grassy Channel, 650	568	122	49.564	5.555.7	3,188.5	15,674	1,026.4	684.8
Average	1	122	87.2	9.8	5.6	27.6	1.9	1.2
Increase:						per ct.	per ct.	per ct.
Naturals	....	....	....	....	....	21.0	18.9	15.3
Grassy Channel Stock	....	....	....	....	....	31.6	18.5	21.5

The increase in length was practically the same in both cases, while the increase in width shows 6 per cent in favor of the Grassy Channel stock. This difference is no doubt due to the fact that the naturals, lot 1, had all *grown singly, and, consequently, were normal in shape*, while the transplanted stock, lot 2, much of which came from crowded seed, showed many individuals with greatly elongated shells. When separated and given a chance to grow singly these oysters at once began to increase in width. The oysters used in this experiment were taken without selection just as they came.

Corrective growth, when separated, of oysters grown under crowded conditions, was first shown by the interesting work of Dr. O. C. Glaser, of the United States Bureau of Fisheries (4).

From table 2 it will be seen that there was little difference in the amount of growth of oysters on the platform and those on the bottom. The 4.3 per cent greater increase in length, and the 2.4 per cent greater

Table 2

A Comparison of Rate of Growth of Oysters on the Platform and on the Bottom

OYSTERS	Number Counted	Period	ORIGINAL Weight	ORIGINAL Length	ORIGINAL Width	INCREASE Weight	INCREASE Length	INCREASE Width
		days	gm.	cm.	cm.	gm.	cm.	cm.
On Platform:								
801 to 900	99	77	7,353	791.2	586.9	2.461.0	147.5	109.0
Average	1	77	74.3	8.0	5.9	24.9	1.5	1.1
						per ct.	per ct.	per ct.
Per cent increase ..	....	....	......	....	....	33.5	18.7	18.7
On Bottom:								
901 to 1,000	97	77	6,856	762.3	562.7	2,237	175.8	118.5
Average	1	77	70.7	7.9	5.8	23.1	1.8	1.2
						per ct.	per ct.	per ct.
Per cent increase ..	....	....	......	....	....	32.6	23.0	21.1

increase in width shown by the oysters on the bottom was probably due to the efforts of the oysters to keep above the soft mud by which they were surrounded. It will be noted that the increase in weight was 1 per cent less than that on the platform.

A comparison of the rates of growth on a platform and on the bottom is being carried on in Elder Creek to check the above experiment. The results of this test, and the practical applications to be drawn from the two experiments, will be given in the next report.

The experimental oysters passed the severe winter of 1919-20 with but very little mortality. When examined in April, 1920, only 15 out of the entire lot were found to have died.

(B) Studies of the Food of the Adult Oyster

On page 421 of the report of this department for 1916 will be found a preliminary note on the food of the adult oyster. It was here shown that the organisms growing on the oyster's shells contribute to the nutrition of the bivalve to a far greater degree than ordinarily has been supposed. Occasional observations of the food of the oyster had been made at this station since 1913, but in view of the many conflicting statements on this subject to be found in the literature, it was decided to begin in 1919 an extensive series of investigations to cover a long period of time, and to study the oyster under all conditions and in every month of the year. These investigations have now been in progress since March, 1919, and will be continued for at least another year. They fall into the following groups:

(1) Microscopical analyses of the stomach contents of oysters immediately upon removal from their natural environment.

(2) A record of the abundance, the seasonal rise and fall, and the behavior of all organisms entering into the food of the oyster.

(3) A determination of the number of food organisms on the oysters' shells and the part played by them in the nutrition of the animal within.

1. Analyses of Stomach Contents

By far the largest part of the work comes under this head. Daily and weekly examinations of the stomach contents of oysters were made from March to September, and monthly thereafter. These monthly microscopical examinations were conducted in a boat at Edge Cove, except during the winter months when the work was carried on in an oysterman's shack on the bank of Elder Creek, Great Bay. In all cases the oysters were examined immediately upon removal from the water.

The technic employed was as follows: The oyster was measured, carefully opened, and its general appearance noted. The fused mantle at the anterior end was slit open to expose the palps, which then were spread apart and the mouth region gently washed with a stream of water from a pipette. A 1-cc. pipette, graduated in hundredths, was inserted through the mouth into the stomach and the contents drawn up and measured. No attempt was made by washing to remove all traces of food held within the stomach folds and liver crypts, as the principal object of these examinations was not to determine the actual number of food organisms contained in the stomach, but rather the relative abundance of the various food organisms, sand, and detritus per cubic centimeter of material. The percentage of total solids; sand,

detritus, animal and plant organisms was then determined by microscopical examination.

The following important observations were made: First, as will be shown in the following section on feeding, the oyster is gathering food most actively on the flood tide, even when the density of the water coming in increases very little, or not at all, over what it was during the ebb. The great majority of the stomach examinations, therefore, were made during this stage. Oysters taken toward the close of the ebb almost invariably had but little or no food in the stomachs, while the maximum amounts were found during the late flood and at high tide. Oysters which had not been feeding for an hour or more previous to examination contained but traces of food in the stomach, showing the relatively rapid passage of food from this organ.

Second, it has generally been understood that the food of the oyster consists almost wholly of material of vegetable origin. During the warm months of the year, however, when ciliary activity is at its greatest, the writer has found that animal food may make up a large part of the oyster's diet. The list includes protozoa, rotifers, roundworms, microcrustacea of many kinds, the larvæ of polychæte worms, of snails, clams and oysters, and of tunicates, and the eggs and early embryological stages of many marine forms. In general, all forms of life in the plankton, which are less than 0.5 mm. in length, have been found in greater or less abundance in the oyster's stomachs.

One would suppose that such active forms as the copepod crustacea and their larvæ would escape from the incurrent stream to the oyster's gills. Many of them do, but when once a crustacean, with its wealth of spines, has come in contact with the mucous of the oyster's gills, it is entangled and rendered helpless. The writer has found in the stomach contents dozens of *nauplius* larvæ which were struggling violently to escape from the entangling mass.

The enzymes of the oyster's digestive tract act upon and digest these animal forms, as is shown by the wealth of shells, carapaces, spines and other bits of animals which have been found in the stomach and intestine.

Frequent examinations were made of the fæces to check possible elimination of undigested animal and plant forms. In nearly every instance some undigested, even living, animal forms and algæ were recovered. In the fæces of one oyster were found 71 oyster larvæ, most of which began actively swimming about when removed to fresh sea water. Several investigators have noted the occurrence of undigested organisms in the intestines of oysters and have concluded that these could not be used as food by the mollusc. Their presence undigested in the fæces, however, is due not to inability on the part of the oyster to digest them, but to the imperfect method of separation of dirt and food in the stomach, by which some of the food organisms are continually being discarded in the process of feeding. This matter has been discussed fully elsewhere (8).

Lotsy (6), in his valuable contribution to our knowledge of what the oyster eats, states that he has never found copepods in the stomachs of oysters, although these crustaceans were abundant in the water over the beds. The writer is unable to account for this, unless, possibly, the oysters examined were taken from deeper waters which did not contain copepods in any considerable numbers. It may also have been that the oysters which he used were less active than those with which the writer has been working. Oysters have been examined from all depths from 2 inches to 10 feet, and no appreciable difference in the types of food eaten has been found. Except during the cold weather all microscopic forms present in the plankton also have been found in the oysters' stomachs.

Third, in common with other animals, the food of which has been studied, the oyster in its feeding shows distinct seasonal variations that are correlated closely with the seasonal variations in the plankton. In the next report, where will be given the results of two years' investigations of the oyster's food, curves will be shown which represent strikingly this parallelism.

In brief, the work of these past 15 months at Edge Cove and Elder Creek has shown the following seasonal changes in the food of the oyster. In late winter and early spring, immediately after the ice has left, filamentous diatoms develop in enormous numbers, while the animal forms are at a low ebb. The oysters at this time are eating no animal forms, save a few protozoa; practically the entire stomach contents are composed of diatoms. As the water warms up the filamentous diatoms rapidly decrease; other species of diatoms and many animal forms increase, the latter now appearing in the oysters' stomachs. During the summer the food of the oysters in Huey's Creek at times consisted of as high as 80 per cent of animal forms.

With the first hard storms of late summer great amounts of eel grass and other plants are torn up and ground to a fine state by wave action and by natural disintegration. The animal plankton shows a sharp decline at this time. Immediately after the violent storm of August 13, 1919, the oysters began eating this plant detritus in large amounts, whereas but very little of this material had been found in the stomachs prior to this time. The number of animal forms eaten shows a marked decline corresponding to the decrease in the number of these organisms in the water.

Peterson (9), working at the Danish Biological Station at Copenhagen, has brought forward the interesting theory that the eel grass, *Zostera marina*, is the ultimate source of food of marine animals. When torn loose and disintegrated it falls to the bottom as detritus, forming a layer of nutriment on the sea floor. Many animals—molluscs, echinoderms, annelids and others are typical detritus eaters, and are almost wholly dependent upon this source of food. Peterson shows that it is possible, therefore, to determine the amount of life a given body of the sea may support by computing the acreage of eel grass present.

Blegvad (2), working with Peterson, has studied the food of the oyster as affected by the eel grass, and he concludes that this bivalve is also a detritus feeder, 95 per cent of its food being composed of this substance. He further states that only when plankton dies and falls to the bottom, becoming detritus, can it be utilized as food by the oyster. He criticises Moore, Lotsy and other American workers who consider diatoms as one of the chief sources of nutriment of the oyster, and holds that only 5 per cent of the oyster's food comes from these organisms.

However true this concept may be for the European oyster, *Ostrea edulis*, it certainly does not hold good for the American oyster, *Ostrea virginica*. At only one season of the year does detritus equal or exceed the diatoms in the oyster's food, and that, as shown above, is in the late summer and early fall after the first hard storms. Full discussion of the theories of Peterson and Blegvad will be deferred until the investigations now in progress have been completed.

With the cooler waters of September the filamentous diatoms, so numerous in the spring, again increase enormously. Oysters examined the last week in September showed but little else in the stomach. With the falling temperature of autumn the ciliary currents of the oyster decrease in strength, with a resultant virtual disappearance of animal organisms, save protozoa, from the food. During this season, as in the spring, the food consists very largely of diatoms, with a small amount of detritus.

During the fall and winter of 1918-19 the oysters in Little Egg Harbor were so lean and poor as to be almost unmarketable. The same was true of most of the oysters along the New Jersey coast. There was a little improvement in the spring of 1919, and in the following summer, after the oysters had thrown out their spawn, they began to fatten very rapidly, so that by the middle of September they were in excellent condition; according to local shippers none better had been sent out in twenty-five years. They were by far the best which the writer has seen in his experience of fifteen years in these waters.

Accompanying this remarkable fattening of the oysters was a great development of filamentous diatoms. On August 16 the plankton catch showed 870,000 of these per 100 quarts of water. By September 26 this organism had increased to such numbers that the straining of 100 quarts of water gave half a tumblerful of thick, dark brown material containing many millions of these forms. On November 28, 17,155,000 of these organisms were found in 100 quarts.

Table 3 gives in detail the number and kinds of organisms found in the stomachs of a few of the oysters examined between March and September, 1919. It would appear from the list here presented that the oyster is a good deal like the small boy—within limits it eats whatever is at hand.

Table 3
Stomach Contents of Oysters

OYSTER NO.	82	83	84	87	88	89	95	96	99	101	105	116	117	118	129	134	157	184	185
DATE	6–27	6–27	6–27	6–13	7–4	7–10	7–17	7–17	7–18	7–22	7–22	7–30	7–30	7–30	8–4	8–6	8–16	8–21	8–21
DENSITY	1019	1012	1012	1016	1018	1011	1016	1016	1014	1012	1017	1017	1017	1017	1018	1018	1014	1015	1015
TEMPERATURE (°F.)	74	78	78	73	82	74	75	75	75	78	78	81	81	81	72	76	77	76	76
TIDE	flood	ebb	ebb	ebb	flood	flood	flood	flood	flood	ebb	flood	ebb	high	high	ebb	flood	high	ebb	ebb
TURBIDITY	.4	.4	.4	.1	.05	.04	.05	.05	.05	.4	.1	.05	.05	.05	.1	.1	.05	.05	.05
ANIMAL FOOD:																			
Copepods	10	18	3	31	9	4	4	150	3	....	10	4	50	....	13	8	36	20	10
Nauplii	1	5	722	34	22	3	144	600	15	4260	100	7	75	75	76	30	72	80	40
Cladocera	17	12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Snail larvæ	58	133	15	1447	....	....	1	....	8	....	....	18	100	100	2	2	....	10	10
Oyster larvæ	1	2	....	....	26	3	510	300	56	10	390	....	....	....	60	....	....	....	....
Clam larvæ	....	....	....	....	....	....	....	....	....	....	20	....	....	....	117	....	....	....	....
Bivalve larvæ (all kinds)	....	....	....	....	....	....	....	....	....	....	....	1064	425	4260	....	29	....	....	....
Annelid larvæ	....	3	....	2	....	....	....	....	....	....	....	3	25	50	10	....	....	....	10
Rotifers	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	216	30	120
Rotifer eggs	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	560
Round worms	3	3	....	4	....	....	3	3	1	....	....	1	....	....	....	....	....	....	....
Eggs, marine forms	33	9	6	....	3	3	....	....	....	....	....	....	....	....	....	....	....	....	....
Peridinium	....	....	....	....	9260	5230	6540	4900	3920	20	1190	....	1000	....	137	28	108	140	170
Other protozoa	....	....	....	....	....	....	....	....	....	....	....	....	58750	....	39,150	97,875	....	....	....
PLANT FOOD:																			
Diatoms	*	*	*	*	*	*	*	2,975,400	*	*	*	*	*	*	822,150	587,250	156,484	37,000	94,000
Filamentous diatoms	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	33,804	15,650	39,150
Desmids	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	97,875	11,268	6,260	7,800
Spores	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4,071,600	....	....	....
Ulva fragments	264	24	4	35	....	....	48	....	....	....	20	2	25	....	....	....	....	....	....
Zostera fragments	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	36	60	....
Detritus	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	50%	75%	60%

* Number not counted, represent 50 to 70 per cent of entire food contents.

Any conditions which result in an increase in the number of food organisms in the water will make for fatter and better oysters. Not much information is available as to the factors which influence the development of marine plankton, but from the extensive studies of limnologists working on fresh-water lakes and streams, we may draw some conclusions as to what is required for the growth of marine forms.

Sea water contains in great abundance many of the inorganic salts required for plant growth. Nitrogen salts, however, are usually present in comparatively small amounts, and as these are as necessary for growth of marine as for land plants, it follows that any increase in the store of available nitrogen results in a marked stimulation of growth. The addition of house sewage, for instance, provided industrial wastes are excluded, causes an enormous increase in the plankton content of a body of water, as shown in the case of Lake Monona, Wisconsin, the Illinois River and the Elbe, in Germany, where comparative surveys have been made. This increase is the direct result of the larger store of essential salts brought in by the sewage, plus the extra amount of available carbon dioxide produced in the oxidation of the organic matter of the sewage.

Oysters and clams brought into waters polluted with house sewage almost invariably fatten rapidly, not, as is ordinarily supposed, because they are eating sewage, but because of the great numbers of food organisms in the water which are deriving their nutriment largely from the sewage. No one eating lettuce grown on fertilized ground would consider for a moment that he was eating fertilizer. In the same way the oyster eats not the sewage, but the microscopic forms for which the sewage is serving as a fertilizer. Oysters grown in waters polluted with house sewage should not, therefore, be condemned either for sanitary or æsthetic reasons, provided, of course, that prior to marketing *they are removed to uncontaminated waters for a sufficient period of time to insure a thorough cleansing of all dangerous bacteria.*

One explanation of the unusual fatness of the oysters in New Jersey from the summer of 1919 to the present time, lies in the greatly increased rainfall beginning with July, 1919. The increased leaching action upon the soil of the supernormal rainfall brings down to the sea larger quantities of all salts from the land. As we have seen, any increase in the available store of essential salts is followed by a corresponding increase in the plankton content of the water. The average precipitation for the State of New Jersey for 1919 was 5.13 inches above the normal, most of the increase coming after July 1.

Conversely, in times of subnormal rainfall, especially when long continued, the decrease in the quantities of essential salts brought from the land is followed by a decrease in the plankton. During an investigation of the causes of mortality among planted oysters in Alabama waters in 1914, the writer found in parts of Portersville Bay,

removed from the direct influence of the Mobile River, comparatively high densities, with little oyster food in the water. Oysters in these localities were all lean and very poor. In the writer's report to the United States Bureau of Fisheries at that time the effect of decreased rainfall upon the stock of available oyster food was dealt with at some length.

Much the same condition obtained in Little Egg Harbor and the New Jersey Coast in general in the fall and winter of 1918-19. As stated above, the oysters at this time were so poor as to be almost unmarketable. The weather reports for New Jersey for 1918 state that the stock of ground water was low, and that at no time during the year was there an excess of precipitation. The total average precipitation for the state from August, 1918, to February, 1919, inclusive, was 7.7 inches below normal. The attention of the reader again is called to the remarkable fattening of the oysters the summer following, together with the great increase in rainfall beginning with July.

It must be borne in mind, however, that increase or decrease in the rainfall to such an extent as to raise or lower the density of the water on the beds above or below the optimum limits for the oyster, would in itself result in poor oysters, regardless of the food content of the water. Such was the case with many of the oysters in the upper Chesapeake region during the fall and winter of 1919-20. The increased rainfall, which was probably the chief factor in making fat oysters in New Jersey and many other parts of the Atlantic seaboard, so far reduced the density of the upper part of Chesapeake Bay as seriously to interfere with the feeding and fattening of the oysters there. These oysters, which usually hold such a high place, in the winter of 1919-20, were bringing as low as 50 cents a bushel on the Philadelphia markets, as against $1.50 for New Jersey stock.

2. Seasonal Variations, Abundance and Behavior of Food Organisms

In order to make the data under this heading as nearly complete as possible, two years' observations will be published in our next report. This is advisable, also, since the past year may be considered in many ways an unusual one.

3. The Food Organisms on the Oyster's Shells

Anyone who has examined a portion of an oyster reef in shoal water, or who has looked down through clear water at a thickly planted bed, must surely have been impressed with the struggle for existence which is there going on. In the case of a natural reef this struggle becomes most acute on account of the excessive crowding, but even on a planted bed, where oysters are close together, the competition for food is most intense. Every oyster, unless it is in a space by itself, must draw in

water the largest part of which has already passed through the gills of hundreds of oysters upstream. A certain amount of rolling over of the upper waters and mixing with the bottom stratum does occur, but in deep water below wave action mixing would not be extensive enough to maintain a full supply of food to the gills of every oyster.

How much water will an oyster pass through its gills in a day? Estimates by other investigators are: Moore, H. F., 40 quarts a day; Grave, C., 333 cc. an hour; Wells, W. F., 50 gallons a day. The writer's figure of 6 quarts an hour for a medium-sized oyster was obtained as follows:

We have seen that when an oyster opens after a period of closure of an hour or more, its stomach is practically empty of food. On July 18

Table 4

Diatoms From the Surface of an Oyster's Shell

Volume	Long Oval	Rectangul'r	Short Oval	S-Shaped	Bilobate	Round
cdm.						
0-1	2,421,717	450 536	394,233	....	....	112,638
1-2	11,563 800	2,309,079	2,252,760	....	168,952	1,070,061
2-3	10,819,429	6,251,409	1,692,520	....	394,233	....
3-4	3,942,330	3 041,226	1,576,932	281,595	113,138	....
4-5	2,421,717	563,190	394,233	563,190	168,952	....
5-6	788,466	112,638	....	509,871	112,638	....
6-7	506,871	168,952	....	394,233	....	....
7-8	394,233	....	....	112,638	....	....
8-9	....	....	....	281,595	....	....
9-10	....	....	....	168,952	....	....
10-11	....	....	....	112,638	....	....
Examples	*Nitzschia angularis*	*Synedra valens*	*Navicula elegans*	*Pleurosigma attenuatum*	*Navicula bomboides*	*Coscinodiscus*

Total, all types: 56,319,000.

all the oysters on platform A closed during the ebb tide, the density falling from 1016 to 1012. Examination made at low water showed the stomachs of the oysters to be entirely empty. As the tide commenced to flow the writer watched for the opening of the oysters, and catching two individuals, 3 to 4 inches long, at the moment of commencing feeding, they were timed for one hour. Meanwhile every 2 minutes a fingerbowl full of the water which was passing over them was dipped up. At the close of the hour the two oysters were opened, the stomachs washed out, and the contents counted. As the protozoan *Peridinium* was abundant and quite constant in numbers in the water at the time, it was taken as the index. The number of these organisms

collected by the two oysters, compared with the number in the water dipped up over the same period of time, gave 6.1 quarts an hour for one oyster, and 5.7 quarts for the other, or, roughly, 6 quarts an hour. As some losses must have been sustained in feeding, this figure is to be considered as conservative. Based on a 20-hour day of feeding (see next section of this report), this would give 120 quarts as the approximate amount of water taken in daily by the oyster. This is a fair mean between the extremes 333 cc. an hour, and 200 quarts a day, as given by Grave and Wells, respectively. The temperature of the water at which this figure was computed was 75° F.

Accepting this as the approximate daily intake of an average oyster, it follows that from this volume the bivalve must obtain its entire food supply for 24 hours. If oysters were solely dependent upon organisms in the plankton, those molluscs on the downstream side, or in the center of a bed with tidal flow in both directions, would soon starve.

Detritus stirred up by currents, and also by the oysters themselves in the frequent snapping of their shells together, no doubt aids materially in maintaining the food supply throughout the bed. But of far greater importance are the organisms which are growing on the oysters' shells, and as a food supply these seem to have been overlooked by nearly all investigators. In our 1916 report (p. 422) the importance of this available source of nutriment is pointed out. The shell of an oyster is a veritable zoologist's paradise, for on it may be found representatives of every phylum in the animal kingdom.

On June 6, 1919, one oyster, 11 by 6 cm., was taken at random from platform A and all adhering growths, mud and slime removed to a dish. This mass was then diluted to known volume and shaken violently for 5 minutes, 1 cc. withdrawn and the organisms counted.

Over 56,000,000 diatoms were present on the shell of this one oyster, and, as nearly all of the species found are motile, their own movements, together with the disturbing action of currents, cause a steady stream of these organisms to be carried to the oyster's gills whenever it opens to feed. Under ordinary conditions a diatom will divide at least once every 24 hours, hence the potentialities of such a food supply may be appreciated.

A good oyster-bed, therefore, has a self-perpetuating food supply which is more or less independent of that of the water passing over the bed. Consequently, as pointed out in our 1916 report, a microscopical analysis of the water over an oyster-bed is not a true measure of the available supply of nutriment, exce
clean-shelled oysters growing on a hard bc

(C) Observations of the Feeding Habits of Oysters

Although the American oyster has been the object of scientific investigation for over forty years, we have almost no accurate information of the physiology of digestion, or of the feeding habits, and how these are affected by environmental influences. Perhaps more speculation may be heard among oystermen, and even scientists, concerning these than of any of the oyster's activities. What are the limits of turbidity, density, temperature and food content of the water within which the oyster will feed, and under favorable conditions how long is it active out of every 24 hours?

Kellogg (5, p. 638) says of the effect of turbidity on the feeding of oysters: "It is my belief, after a good many years of observation, that lamellibranchs are able to feed only when the surrounding water is relatively free from solid particles; just how free, in a given case, I am not able to say, and the difficulties in determining the matter are great if not insurmountable."

Preliminary experiments under laboratory conditions demonstrated the futility of attempting to solve any of these problems with the oysters under artificial conditions. Probably few marine animals are more sensitive to environmental influences than is the oyster. Adapted as it is for a sessile mode of life, unable to move away from unfavorable surroundings, dependent on the currents to bring to it food and oxygen, and to carry off wastes, the very existence of the oyster depends upon its ability to perceive slight changes in its environment and to react accordingly.

It became necessary, therefore, to perform the experiments upon the oyster while in its native environment. Accordingly, an apparatus was designed to register the shell movements of the oyster while it was lying on a natural oyster-bed in Hucy's Creek near the stern of the floating laboratory. Ten of the largest oysters procurable—five Huey's Creek Naturals and five Great Bay plants—were prepared for this experiment.

With a fine dentist's drill two holes were bored obliquely through a ridge of the shell near the margin of the valves, great care being taken not to perforate the inner nacreous layer. A copper rivet was then wired securely into place over the holes. The left valve of each oyster was next imbedded in a cement block, 6 inches square by 2½ inches deep, leaving the margin of the shell entirely free, and about half an inch above the surface of the block (plate IV, fig. 2). The oysters were imbedded on May 5 and put out on platform B, where they were left undisturbed for 2 months.

All ten of the oysters were alive at this time and had put out a vigorous new growth. The cement blocks were heavily coated with slime, seaweeds, hydroids and tunicates. It is safe to assume, therefore, that the oysters were in no way affected by the operations of embedding and fixation of the rivet, but were functioning as normally as though attached to a natural reef.

An instrument for transmitting and recording the movements c the oyster's shell was constructed as follows: In figure 1 is shown tl method of attachment of the rivet to the shell. A clamp with ac justable screws, allowing free movement in one direction, was fitte into sockets in the free end of the rivet. A short piece of brass ro was fastened with a swivel to the clamp, thus permitting movemer *in direction at right angles to the first*, virtually a universal joint.

Figure 3 shows the imbedded oyster ready for its position on tl

Table 5

Size of Oysters in Feeding Experiments

Oysters	Source	Date in Block	Weight	Length	Width
No.			Gm.	Cm.	Cm.
1501	Huey's Creek Naturals	5-5-19	320	14.2	10.0
1502		5-5-19	246	12.2	8.5
1503		5-5-19	243	11.2	7.5
1504		5-5-19	314	12.0	9.5
1505		5-5-19	231	11.5	8.7
1506	Great Bay Plants brought to Huey's Creek 3-31-19	5-5-19	307	14.5	10.2
1507		5-5-19	288	12.5	10.2
1508		5-5-19	288	12.2	7.7
1509		5-5-19	291	13.0	9.7
1510		5-5-19	220	11.2	7.2

bottom, with a connecting rod of 5 feet of ⅛-inch straight glass tubin; leading from the universal joint to the recording instruments abovc A cage of ½-inch galvanized iron wire, omitted from the photograpl for sake of clearness, was placed about the platform on which th oyster rested to prevent disturbance by inquisitive crabs.

The upper end of the connecting rod was attached to a recordin; lever, consisting of a brass rod pivoted in the middle, and fitted witl mercury electrical contacts at either end. By means of a counter weight the entire apparatus with connecting rod and universal join was brought into an exact balance before attaching to the oyster, i being necessary for the latter only to overcome the very slight resist ance of the central pivot in order to move the lever freely in eithe: direction. To one end of the lever was attached an inking pen whicl traced a continuous record on the drum of the chimograph. Th latter instrument was made to revolve once in 7 hours by cog-wheel: fastened to the minute hand of a Big Ben alarm-clock (plate V, fig. 2)

The electrical contacts were designed so that whenever the wire a either end of the lever dipped into the mercury a circuit was complete through the central contact at the pivot. Wires were led to an electri bell in the floating laboratory, where, by means of a double-throw switch, the apparatus was always in readiness to warn the experi- menter of an opening or closing of the oyster's shells.

Figure 1 gives a view of the complete apparatus with the oyster in position on the bottom of the creek. The bilge pump for drawing up water samples was set with the intake at the same level as the valves of the oyster, about 4 inches above the bottom.

The writer is deeply indebted to Dr. S. H. Chase, of Madison, Wis., and to Dr. W. D. Rice, of New Brunswick, N. J., for furnishing dentist drills and handpieces, as well as for valuable suggestions as to the method of attachment of the rivet to the oyster's shell. To Dr. W. J. Meek, of the University of Wisconsin, he is indebted for inking pens adapted for outdoor use.

Experiments were begun on July 7, 1919, and terminated on August 13, with the complete destruction of the recording apparatus during the very violent storm and high tide of that date. In this period of observation three of the ten oysters were used—Nos. 1501, 1507 and 1509. The experimental procedure consisted of keeping a continuous record day and night of the shell movements of the oyster, and at each complete opening or closure of the shell to draw up a water sample for determination of temperature, density, turbidity and food content. A complete record of water, tide and weather conditions was taken simultaneously. With the chimograph over 140 feet of continuous tracing were taken, showing the nature and extent of the oyster's shell movements at all times and under all conditions.

A turbidity standard was made up from the surface layer of the mud of Huey's Creek by using 1.6, 1.4, 1.2, 1.0, 0.8, 0.6, 0.4, 0.2, 0.1 and 0.05 gm. of dry material per liter of water. Samples of water to be tested were matched against these standards and given the corresponding value. The waters of Huey's Creek were found to vary from about 0.05 gm. in calm weather to 0.4 gm. per liter in times of high winds.

The summary of observations on the shell movements of oysters given below is based on three individuals, but whenever the stage of the tide permitted it the 1,000 experimental plants on platform A were examined for confirmation. In the great majority of instances there was striking agreement between them, and such cases must be considered as holding good for large numbers of oysters.

Summary of Observations on Feeding

Observations made upon three experimental oysters attached to the recording apparatus, and checked as often as possible by the 1,000 tagged plants on platform B, bring out the following facts:

First. During 21 days in which every minute of the time, day and night, was accounted for, the three oysters remained tightly closed for a total of 84 hours, 16 minutes, or an average of 4 hours, 40 seconds a day.

Second. The times of complete cessation or of commencement of feeding show a rather definite correlation with the stage of the tide. This factor apparently operates independently of the changes in den-

sity of the water which usually occur with the ebb and flow. The slight decrease in density often observed would not in itself cause closure, as the density at low tide in Huey's Creek, except in very wet weather, is well above the minimum at which oysters will cease feeding. Table 6 shows that out of a total of 49 closures, 61 per cent occurred during the ebb and 12 per cent at low water. As against these only 20 per cent occurred during flood tide and 6 per cent at high water. Out of a total of 46 openings, 56 per cent occurred during the flood and 6 per cent at high water, as against 32 per cent during the ebb tide and 4 per cent at low water.

These figures lend support to the commonly accepted theory that bivalves feed most actively during the flow of the tide, and are less

Table 6

Shell Movements of Oysters as Correlated With Tides

Stage of Tide	CLOSURE		OPENING	
	Number	Per cent	Number	Per cent
Ebb	30	61.2	15	32.5
Low	6	12.2	2	4.4
Flood	10	20.4	26	56.5
High	3	6.2	3	6.5
Total	49		46	

active, or even quiescent, during the ebb. As everyone knows who has *tonged for hard clams, these molluscs come to the surface of the* bottom with the turn of the tide to flood. Further evidence in the case of the oyster lies in the nature of the tracings on the chimograph during these periods. (Compare curves in figs. 2 and 3.)

Third. There appears to be a certain amount of correlation between the times of opening and closure, and the hour of the day and night. So striking is this in some cases that the period from 11 p. m. to dawn may almost be looked upon as a time of rest, or, at least, of greatly lessened activity. In table 7 are given 46 closures and openings classified according to the period in which each occurred. It will be seen that 50 per cent of the closures took place in the 5½ hours between 11 p. m. and dawn, while only 6 per cent came during the earlier 3½ hours of darkness from sunset to 11 p. m. The remaining 44 per cent were equally divided between the morning and afternoon periods.

The hours of inactivity on 50 per cent of all the days were confined to periods 1 and 2. On the other 50 per cent of the days these

times of inactivity were divided into two or more shorter periods occurring in all four periods. Hence, in nearly ever case where the oyster closed before or shortly after midnight it opened again before dawn, thus explaining the relatively large number of openings, 28 per cent taking place in the first period.

Fourth. On account of the unusually wet weather in July and August, it was possible to obtain some important observations as to the effect of wide variations in density on the activity of the oysters. Upon several occasions the water in Huey's Creek became absolutely fresh at low tide, to return rapidly with the flood to the density of the waters of the bay, which varied from 1016 to 1019 during the course of the experiments. Table 8 gives in summary six openings and closures during periods of low density.

The lowest density tolerated by the oysters on opening was 1010,

Table 7

Shell Movements of Oysters as Correlated With Time of Day or Night

	Period	CLOSURE		OPENING	
		Number	Per cent	Number	Per cent
1	11.01 p. m. to 4.30 a. m. (dawn)	23	50	13	28
2	4.31 a. m. to 11.00 a. m.	10	22	23	50
3	11.01 a. m. to 7.30 p. m. (sunset)	10	22	6	14
4	7.30 p. m. to 11.00 p. m.	3	6	4	8

although on July 15 and 16 closures were not effected until the water had fallen to 1008 and 1009, respectively. For oysters growing in water of an average density between 1015 and 1020, 1008 may therefore be considered as the minimum below which no feeding will occur, and 1010 may be taken as the critical density for these oysters, since no opening occurred in water lower than this. On the twenty-third the oysters remained closed for nearly 5 hours, during which time the density fell to 1006, but no opening took place until the incoming tide had raised the density again to 1010. It is important to emphasize that the observations given in table 8 were all checked by the 1,000 oysters on the platform, and must therefore be considered as typical for these oysters as a whole.

Fifth. The effects of suspended matter upon the feeding of the oysters was shown to be quite at variance with the conclusion of Kellogg (5, p. 641), that "* * * the volume of material, and not its nature, as possible food determines whether or not it shall be taken into the stomach." It was the writer's opinion, prior to taking up these experiments, that oysters would not feed in muddy water, but remain partially or wholly quiescent until the water had cleared.

Table 8

Shell Movements of Oysters as Correlated with Changes in Density of Water

	CLOSURE				OPENING			
Date	Hour	Density	Temperature	Tide	Hour	Density	Temperature	Tide
			°F.				°F.	
July 15	5.30 a. m.	1011	74	low falling	7.30 a. m.	1011	74	low rising
15	6.00 p. m.	1008	78	low	7.06 p. m.	1013	76	flood
16	6.10 a. m.	1011	74	low falling	8.17 a. m.	1014	74	flood
16	6.50 p. m.	1009	78	low	7.55 p. m.	1011	78	flood
19	6.00 a. m.	1014	74	ebb	9.13 a. m.	1010	77	low
23*	9.23 a. m.	1016	76	ebb	2.06 p. m.	1010	80	flood

* Density at low tide, 1.30 p. m. this date, 1006. The period between hour of closure and succeeding opening equals the time of inactivity.

While this work was being carried on there were several hard easterly storms which stirred up large quantities of mud in Little Egg Harbor, so that at the flood tide much suspended matter was carried into Huey's Creek. In spite of the fact that the turbidity rose from *0.05 to 0.4 gm. per liter within a few hours, the oysters still continued* to feed actively. The only apparent change was the somewhat more frequent ejection of mud as shown by the chimograph tracing. That the oysters were taking food into their stomachs which had been separated quite largely from other suspended matter, and were not rejecting everything as Kellogg would suppose, was shown by examination of stomach contents of oysters on the platforms.

This opens up the whole question of the function of the palps of the oyster; *do they, or do they not, exercise a selective action in sorting* over the matter received from the gills, and rejecting foreign matter, pass on into the œsophagus materials which are suitable as food? Kellogg believes that they do not, and no one can read his excellent paper on ciliary mechanisms in lamellibranchs without feeling that he puts up strong evidence.

Caswell Grave believes that the palps may exercise some selective action, and support of this assumption comes from the excellent work of Allen (1) on the food and feeding of the fresh-water mussels, and also the investigations of Cobb (3) who has shown that the palp of *Anodonta,* the fresh-water mussel, is equipped with an autonomic nervous innervation as complex and as efficient as that of the vertebrate heart. As the writer hopes to consider this controversy in detail at some later date when he has completed his own evidence, he merely wishes to call the attention of the reader to the question in order that he may weigh for what it is worth, the evidence here presented.

Table 9

Shell Movements of Oysters as Correlated With Number of Food Organisms in the Water

	Copepods	*Nauplii*	Bivalve *Veligers*	Snail *Veligers*	*Peridinium*	*Diatoms*
Opening ...	50	233	58	83	817	158,800
Closure ...	62	191	38	125	570	181,800

The figures represent the number of organisms per liter of water; average of all samples taken with bottom pump.

It is of interest to note that the oysters often closed in waters of relatively low turbidity to reopen in water containing a much larger amount of sediment. The experiments as a whole fail to show any evidence that an increase in turbidity within the limits noted causes a cessation of feeding.

Unfortunately the last stages of this experiment, in which it had been planned to stir np the creek bottom artificially and determine the limits of tolerance of the oyster to suspended matter, were cut short by the destruction of the apparatus as above explained. It is hoped that this work will be continued next season.

Sixth. Temperature within the limits observed during the experiment (69° to 90° F.) apparently did not operate as an independent factor in controlling the intake of food. The extremes, 69 and 90,

were each observed but once during the entire period, for most of the time the temperature fluctuated between 72° and 78° F. As will be shown in the report for next year, the critical temperature for the oyster, at which a marked decrease in the rate and duration of feeding is apparent, is over 20 degrees below the minimum, 69° F., observed in this experiment.

Seventh. What effect, if any, does the food content of the water have on the feeding of the oyster? Will the bivalve cease to feed in waters of low food content to commence again when the food supply is increased? Has the oyster any means of testing the incoming water for the presence of food? Water samples pumped up from the bottom at the moment of opening or closing and analyzed for food content, failed to show any correlation between the time of opening or of closing and the food content of the water. In no case did the samples taken at closure show any marked lack of food. Often the oysters closed when the water was very rich in food organisms, to open again when these were much less numerous.

Laboratory experiments have shown that oysters will continue to draw in water vigorously for hours after every particle of suspended matter has been removed from the water by their activity. Although this continued activity is probably chiefly for the purposes of respiration, no evidence has thus far been obtained which would indicate that a decrease in the amount of food present, or even its entire absence, causes a decrease in the rate of water intake. On the contrary, oysters kept in filtered water will open more widely than usual and draw in water even more vigorously than when much food is present. Apparently hunger stimulates the oyster to greater activity. There was no essential difference in the number of food organisms present in the water on closing or opening.

What, then, is the physiological meaning of these periods of activity? Closure has taken place in the great majority of cases when the conditions of density, turbidity and food content were optimum. The possibility of lack of oxygen being the cause must be ruled out on account of the shallowness of Huey's Creek, the rapid current, and the lack of any excess of organic material to use up available oxygen. Furthermore, Dr. Mitchell (7) has shown that the oxygen requirements of oysters are low as compared with other marine organisms.

It is possible that the periods of closure observed in these oysters may have been due to an unknown factor, or to the combined effect of several factors not yet fully appreciated. But the writer believes the evidence from all sources indicates that the periods of inactivity, which occur under conditions favorable for feeding, are to be looked upon as true rest periods. The chimograph record shows that closures were almost always effected after periods of active feeding, and were preceded always by a rapid series of shell movements to free the mantle cavity of all extraneous matter.

An examination of the stomach contents of oysters, taken from the platform, which had closed approximately at the same time as the individual in the apparatus, showed much food present. Examined immediately after opening, provided the period of closure was an hour or more, the stomachs revealed little or no food. The period of inactivity, therefore, may be utilized for digestion of food acquired in active feeding, though the process of digestion is probably more or less continuous as long as any food remains in the stomach.

Of the 140 odd feet of chimograph tracing made by the three experimental oysters, only a few isolated portions are reproduced herewith to illustrate the behavior of the bivalves under various conditions. In order properly to interpret these tracings it is necessary to understand how the oyster feeds, and in what manner it gets rid of rejected matter.

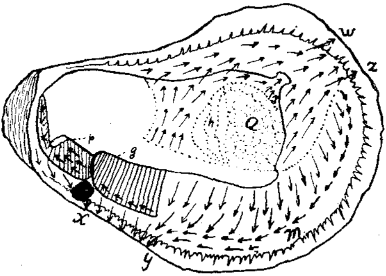

FIG. 1. ADAPTED WITH SLIGHT MODIFICATIONS FROM KELLOGG'S FIGURE 48 (REFERENCE 6). OYSTER LYING IN ITS RIGHT VALVE, WITH ENTIRE LEFT MANTLE, AND MOST OF GILLS ON BOTH SIDES, REMOVED.

a, adductor muscle.
g, gills.
h, heart.
p, palps or lips.
m, mantle (left).
w-z, region for expulsion of excurrent water.
x-y, region of outgoing ciliary tracts for carrying off material not taken up by palps. Black spot above *x* represents material accumulated prior to an ejection reaction.

With its shells open from a mere crack to as much as a quarter of an inch, the oyster draws in a current of water by the action of millions of rapidly beating cilia. The water enters the shells along the entire margin from *x* to *z* in figure 1, and passing through minute

openings in the gills is carried into a chamber lying above the gills from which it is expelled in the region *z* to *w*, as indicated by the arrows in the figure. All suspended particles, except the most minute, are strained from the water as it passes through the small openings between the gills, and becoming entangled in mucous, are passed in strings forward to the palps. At this point the strings are either picked up by the palps and led into the mouth, or failing this are caught by

FIG. 2. CURVE OF OYSTER 1507, JULY 24, 1.30 TO 2.30 A. M., SHOWING SLOW RATE OF FEEDING ON THE LATE EBB TIDE. TURBIDITY THE SAME AS IN FIGURE 3. CURVE GIVES CLOSURE OF OYSTER AT LOW WATER. (In this and the following curves 1 cm. is equivalent to 10 minutes.)

FIG. 3. SAME AS FIGURE 2 AFTER A CLOSURE OF 1 HOUR, 9 MINUTES, THE OYSTER OPENED AND BEGAN ACTIVELY FEEDING ON THE FLOOD. NO APPRECIABLE INCREASE IN TURBIDITY ABOVE THAT IN FIGURE 2.

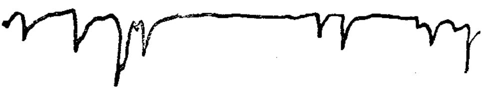

FIG. 4. CURVE OF OYSTER 1501, AUGUST 4, 11 TO 12 P. M., SHOWS NUMBER OF MUD EJECTIONS WITH TURBIDITY AT 0.1.

the outgoing ciliary currents of the mantle and carried to the mantle edge between *x* and *y* where they gradually accumulate, or are carried over the edge and dropped from the mantle cavity. The black spot above *x* in the figure represents a mass of this rejected material accumulated below the tips of the palps. At irregular intervals the oyster suddenly ceases to draw in water, and with a quick closing movement of its shell forces out a part of the water in the mantle cavity carrying with it the accumulated waste at *x*. Many readers will recall having seen oysters at low tide, when barely covered, squirting streams

If only a portion of the waste is removed in one ejection the oyster will often follow this immediately with a second or third. Where some irritating substance comes to lie in a less accessible position the oyster

FIG. 5. SAME AS FIGURE 2, 3 TO 4 P. M., MUCH MORE FREQUENT EJECTIONS WITH TURBIDITY AT 0.2.

FIG. 6. CURVE OF OYSTER 1509, 7 TO 8.30 P. M., ILLUSTRATING A CLOSURE OF 45 MINUTES. NOTE THE RAPID SERIES OF EJECTIONS JUST PRIOR TO CLOSING.

may exhibit a whole series of rapid ejections in the effort to be rid of the irritation.

Following very quickly upon each ejection, the oyster again begins active feeding, the shell soon regaining its former position. The down strokes on the tracings, therefore, represent ejection reactions of a greater or lesser magnitude, and from an observation of their extent and frequency, together with a knowledge of the turbidity of the water, it is possible to determine the rate of feeding.

No attempt is made in this report to analyze the many peculiarities presented by these tracings, some of which are of undoubted physiological importance, for to do so would far overstep the allotted space. It is hoped that after several more years of investigation a full discussion of this most interesting phase of the oysters' many activities may be published.

In concluding this section of the report three results of these experiments which have important economic bearing should be emphasized. First, we have seen that the oyster is active for an average of 20 hours out of the 24, and that during this time it strains approximately 120 quarts of water. It was shown that at densities below 1008 the oysters under experimentation closed tightly and refused to feed again until the density rose to 1010. There are in this country, especially during a wet season, hundreds of acres of oyster-producing ground which are subjected for a part of each tide to densities below

this. Every hour that the density of the water remains below 1008 is to be considered as a non-productive hour as far as the oyster is concerned. Any great curtailment of the hours of feeding must become apparent in lessened growth and a failure to fatten properly. It is safe to assume, therefore, that no oyster ground will in the long run prove profitable in which the waters fall below 1008 for any time considerably in excess of 4 hours a day. No investment would pay every oyster-producer a higher premium than the purchase of an ordinary salinometer or hydrometer, registering from 1000 for distilled water to 1030. The Arthur H. Thomas Co., of Philadelphia, Pa., puts out an instrument which combines both hydrometer and thermometer so that the temperature as well as the density may be taken at one reading.

Second, oysters shipped from the beds without floating never keep as long as do floated oysters. On reaching their destination many of the unfloated stock are found to have lost their liquor.

One reason for this is obvious. When the oyster is shipped without giving it an opportunity to cleanse itself, much mud and grit is enclosed in the mantle cavity. In trying to rid itself of this irritating matter by snapping its shells, while in the sack or barrel, the oyster loses the water from between its shells.

Third, it was shown that oysters continued to feed actively in waters bearing as high as 0.1 gm. of suspended matter (dry weight). Waters carrying this load were observed only during hard wind storms, 40 miles an hour and over, and would be classed by the writer as decidedly muddy. It is evident, therefore, that Dr. Kellogg's statement, above cited, that lamellibranchs are able to feed only "when the waters are comparatively clear," must be qualified, at least until this investigator specifies what he means by "comparatively clear waters."

Provided the oysters are not imbedded in a soft or shifting bottom, where they would soon be smothered, there is no reason why profitable oyster beds may not be located in regions where the water becomes quite roily as a result of wind action. Little Egg Harbor, of which Edge cove is an arm, has for the most part a very soft mud bottom, and as most of this body of water is less than 6 feet deep, much sediment is stirred up and transported whenever the wind blows. During one severe wind-storm in the summer of 1919, over an inch of mud was brought in and deposited on the bottom of Huey's Creek in less than 24 hours. The oysters on the platforms, being above the bottom, were in no way harmed by this deposition, and apparently were feeding throughout most of the storm.

The oyster is thus well equipped in its mechanism for waste ejection, to deal with mud held in suspension, but against a soft mud bottom it has no protection. Most of the readers have seen the mud pockets on the inner surface of oyster shells, where a thin layer of horny material has been secreted by the oyster to wall in the offending matter which it was unable to eject. Oysters grown on a soft bottom

often show many of these pockets; and such oysters are almost invariably lean and in poor condition. The mud which is pressing in on all sides interferes seriously with feeding, since much of the food gathered is rejected along with the sediment in the struggle of the oyster against the mud.

In the summer of 1914, while investigating the causes of mortality among planted oysters in Alabama waters, the writer found acres of these bivalves all but covered by the very soft mud of the bottom. When opened these oysters were so lean and poor that it was possible to read coarse newspaper print right through the tissues of a large oyster.

If oysters are planted on a bottom of sufficient firmness to support them they will have no difficulty in coping with suspended matter. The failure of oysters to fatten on certain grounds should not be laid to an inadequate food supply until it has been demonstrated that the feeding of the bivalves is in no way hindered by the character of the bottom. The fact must never be lost sight of that the oyster is not a bottom form like the clam. It has in the course of evolution become adapted for its life on a reef where it is far above mud and shifting sands. It is a highly specialized form, and hence the more closely we simulate the hard bottom, the swift currents, and the raised position of the natural home of the oyster, the better will be our success in its artificial culture.

(D) Further Investigations of the Larval History of Oysters

As most of the time during the past season was spent in a study of the food and feeding of oysters, the only work done with the larvæ was to record the number and stage of advancement of those obtained in the plankton sample taken at high tide each day at the laboratory.

The first larvæ appeared on May 22 when 3 were found per sample of 100 quarts of water at 1016-68° F. The numbers continued low until June 5, when with the water at 1018-80, 300 larvæ were taken per sample. There followed a period of lower water temperatures, averaging 74° F., with but few larvæ until July 2, when the temperature rose to 78, followed by 81 on July 3, and the sudden appearance of 800 larvæ per sample. Three days later came the first heavy spawning of the season, with water at 1019-83° F., over 24,500 larvæ 24 hours old. This enormous number is partly accounted for by the fact that the oysters on the platforms were spawning at this time. On the preceding day large numbers of developing oyster eggs of from 2 to 8-cell stages, were recovered from the water some 20 feet downstream from the platforms.

Table 10

Continuous Record of Shell Movements of Oysters for one Week

Date	Closure: Hour	Closure: Density	Closure: Temperature	Closure: Turbidity	Closure: Tide	Closure: Height	Opening: Hour	Opening: Density	Opening: Temperature	Opening: Turbidity	Opening: Tide	Opening: Height	Total Time Closed
ster No. 1501													
g. 4	7.40 a. m.	1018	72	.1	ebb	2:4	9.50 a. m.	1014	74	.2	ebb	1:8	2 hr. 10 min.
5	5.51 a. m.	1018	74	.05	ebb	3:3	9.20 a. m.	1017	75	.1	ebb	2:2	3 hr. 29 min.
6	12.53 a. m.	1016	75	.2	ebb	2:2	6 08 a. m.	1017	76	.05	high	3:15	5 hr. 15 min.
7	1.20 a. m.	1017	76	.1	ebb	2:2	4.57 a. m.	1018	75	.05	flood	3:4	3 hr. 37 min.
ster No. 1509													
g. 8	12.46 a. m.	1017	78	.1	ebb	2:7	2 22 a. m.	1015	78	.2	flood	2:1	
	6.30 a. m.	1018	78	.05	flood	3:2	8.30 a. m.	1018	78	.05	ebb	3:3	
	8.27 p. m.	1018	78	.05	high	4:2	9.12 p. m.	1018	78	.05	ebb	4:0	4 hr. 21 min.
9	2.48 a. m.	1017	74	.05	low	1:8	5.15 a. m.	1018	72	.05	flood	2:10	
	7.40 p. m.	1018	76	.1	flood		10 15 p. m.	1019	77	.05	ebb	4:0	5 hr. 19 min.
10	2.12 a. m.	1018	72	.05	ebb		5.00 a. m	1019	72	.05	flood	2:0	
	8.39 p. m.	1019	76	.05	flood	3:10	11.09 p. m.	1019	76	.05	ebb	3:11	5 hr. 18 min.

Height of tide represented in feet and inches above mud of bottom.
Low tide about 1.8, high tide about 4:3, valves of experimental oyster were at 0.4.
Turbidity figures represent grams of dry matter per liter.

A second heavy spawning occurred on July 16, with the water at 1016-76° F., the sample on the 17th giving 8,200 of the early embryos. Active spawning, as revealed by the presence of 24-hour embryos continued quite steadily from this time until August 10. As shown in table 11, on July 28, the number of larvæ rose to 45,500 per 100 quarts, breaking all records for this station. On the same date 11 large larvæ ready to set were found. The remainder of the spawning season is given in table 11, together with the number of spat setting during the previous 24 hours on newly planted shells. Thus the number of spat given under each date represents those embryos which set on the day previous.

Table 11

Studies of Oyster Larvae

Date	Water*	Oyster Embryos per 100 Quarts				Set
		Small	Medium	Large	Ready to Set	No. per Shell
July 27	1017-81	24,000	0	750	1	
28	1016-84	44,200	1,300	0	0	
29	1017-81	18,500	1,700	0	11	
30	1017-81	1,700	1,000	15	9	2
31	1017-78	1,000	2,300	35	4	1
Aug. 1	1017-78	100	0	71	4	0
2	1017-76	1,200	0	159	23	1
3	Absent from laboratory; no records except shell.					6
4	1018-77	1,200	0	3	3	3
5	1018-76	350	0	15	3	2
6	1018-76	800	1	0	0	11
7	1018-78	350	0	0	1	2
8	1018-78	2,000	0	0	0	0
9	1019-72	1,700	0	0	0	1
10	No further setting occurred.					

* Figures give density-temperature.
All samples from surface at full high tide.

The spat which set over the period from July 30 to August 9 were of the lot produced during the active spawning which followed July 16.

Had the oyster growers of this region taken advantage of the information given them from this station during the latter half of July, and planted shells, a fine lot of spat could have been secured, as setting took place continuously for over a week. As it was, there was only a slight catch in the mouths of the several creeks entering Little Egg Harbor. Very little of this spat lived through the severe winter which followed.

IV. Summary

1. A survey of the waters of upper Barnegat Bay showed many oyster larvæ swimming actively about with a water density of 1004.

2. Studies of the rate of growth of 150 natural and 850 transplanted oysters bring out the following facts:

Naturals in 133 days increased 21 per cent in weight, 18.9 per cent in length, 15.3 per cent in width. Transplanted stock in 122 days increased 31.6 per cent in weight, 18.5 per cent in length, and 21.5 per cent in width.

3. The work of Dr. Glaser on corrective growth of misshapen and elongated oysters, in so far as his experiments were repeated, is confirmed.

4. There was no appreciable difference in the rate of growth of oysters on the bottom from that of oysters on the platform above.

5. Examination of the stomach contents of oysters brings out the following observations:

(*a*) The largest quantities of food are to be found in the stomachs of oysters during the flood tide. At summer temperatures the stomach may be emptied within an hour after cessation of feeding.

(*b*) During the summer months the oysters were found to eat much *animal food, including protozoa, rotifers, round worms, microcrustacea*, and the eggs and larvæ of polychæte worms, snails, clams, oysters, and tunicates, besides the early embryological stages of other marine forms. The stomach contents of oysters were found to be a fairly accurate index of the organisms present in the plankton. Animal food made up as high as 80 per cent of some individual oysters.

(*c*) The food of the oyster shows distinct seasonal variations which are correlated with the rise and decline of the animal and plant organisms in the water, and with the tearing loose and grinding up of the eel grass in the fall.

(*d*) The conclusions of Petersen and Blegvad that plankton organisms make up only 5 per cent of the oyster's food, and then only when dead and in the form of detritus, are shown to be untenable as applied to the American oyster.

(*e*) Conditions causing an increase in the plankton content of a body of water are discussed briefly. Shellfish placed in waters polluted with house sewage fatten rapidly, not because they are eating sewage, but because of the larger number of food organisms which are growing at the expense of the sewage.

(*f*) Increased rainfall is given as one reason for the unusually fat oysters in New Jersey since September, 1919. The action of a supernormal, or of a subnormal, rainfall in bringing greater or lesser quantities of essential salts from the land, is shown to have a direct effect upon the abundance of organisms in the water, and consequently on the fatness of oysters.

6. Oysters were found to strain approximately 6 quarts of water an hour, or 120 quarts a day.

7. A study of the food organisms growing on the shells of the oyster revealed over 56,000,000 diatoms on a single oyster.

8. The shell movements of oysters were studied while the molluscs were lying on a natural oyster bed. The following observations were made:

(*a*) Oysters averaged 20 hours' activity out of the 24.

(*b*) Seventy-three per cent of all complete closures occurred during the ebb tide and low water, as against 27 per cent for the flood tide and high water. Sixty-three per cent of all openings occurred during the flood and bigh water, in contrast to 37 per cent on the ebb and at low water.

(*c*) Fifty per cent of all closures occurred between the hours of 11 p. m. and dawn, this being the period of greatest inactivity of the oyster.

(*d*) Oysters were shown to close tightly when the density of the water fell to 1008 or below, and not to open until it had risen again to 1010. Oyster beds, to be profitable, should not fall below this figure for more than 4 hours a day.

(*e*) Oysters continued to feed in waters bearing as high as 0.4 gm. of suspended matter per liter (dry weight). The conclusions of Kellogg in this connection, are called in question.

9. In spite of the wet summer large numbers of oyster larvæ were found, breaking all records on July 28, with 45,500 larvæ per 100 quarts. Oyster larvæ set continuously in Edge Cove from July 30 to August 9, 1919.

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PLATE I

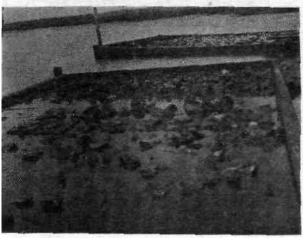

Fig. 1

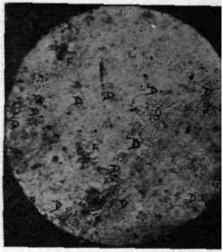

Fig. 2

FIG. 1. PLATFORMS A AND B IN HUEY'S CREEK PHOTOGRAPHED AT LOW TIDE. TAGGED OYSTERS 1 TO 900 AT FARTHER END OF PLATFORM B IN THE FOREGROUND. OYSTERS 1501 TO 1510 SET IN CEMENT BLOCKS LIE IN THE CENTER OF THIS PLATFORM.

FIG. 2. CRUSTACEAN LARVAE IN VARIOUS STAGES OF DIGESTION. FRESH LARVAE MARKED F, PARTIALLY DIGESTED INDIVIDUALS MARKED D.

Fig. 3

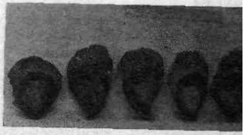

Fig. 4

FIG. 3. GROUP OF OYSTERS SHOWING CORRECTIVE GROWTH. FROM LEFT TO RIGHT THEY ARE: No. 328, 401, 620, 339, 661. BLACK LINE SHOWS MARGIN OF SHELL AT BEGINNING OF EXPERIMENT. TIME OF GROWTH 122 DAYS.

FIG. 4. GROUP OF WELL SHAPED OYSTERS SHOWING LARGE GROWTH IN 122 DAYS. THEY ARE FROM LEFT TO RIGHT: No. 103, 51, 363, 740, 251. BLACK LINE AS IN FIGURE 3. SIX-INCH RULE IN BACKGROUND FOR COMPARISON.

PLATE II

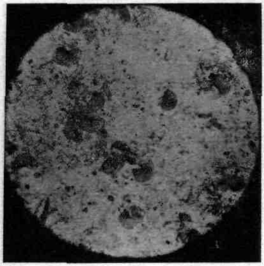

Fig. 1

Fig. 2

FIG. 1. STOMACH CONTENTS OF OYSTERS; SNAIL LARVAE.

FIG. 2. STOMACH CONTENTS OF OYSTER; PART OF 63 OYSTER LARVAE READY TO SET, TAKEN FROM THE STOMACH OF ONE OYSTER.

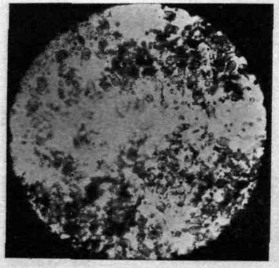

Fig. 3

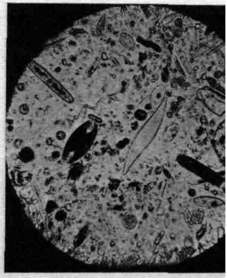

Fig. 4

FIG. 3. STOMACH CONTENTS OF OYSTER; PART OF SEVERAL THOUSAND PERIDINIUM FROM STOMACH OF ONE OYSTER.

FIG. 4. STOMACH CONTENTS OF OYSTER; PORTION OF MICROSCOPIC FIELD UNDER HIGH POWER SHOWING PERCENTAGE AND TYPES OF DIATOMS EATEN.

PLATE III

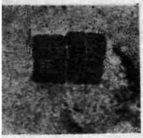

Fig. 1

Fig. 2

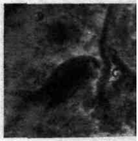

Fig. 3

FIG. 1. STOMACH CONTENTS OF OYSTER; PIECE OF GREEN ALGAE NEARLY 1 MM. SQUARE.

FIG. 2. STOMACH CONTENTS OF OYSTER; LARGE COPEPOD IN FIRST STAGES OF DIGESTION.

FIG. 3. STOMACH CONTENTS OF OYSTER; FRESH COPEPOD AT A, CARAPACE OF DIGESTED COPEPOD AT B. FRAGMENTS OF PLANTS AND DETRITUS AT C.

Fig. 4

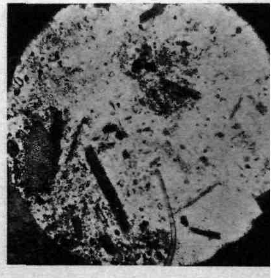

Fig. 5

FIG. 4. PORTION OF SLIME REMOVED FROM SHELL OF OYSTER. SHOWS A FEW DIATOMS CLASSIFIED IN TABLE 4.

FIG. 5. FRAGMENTS OF ZOSTERA AND OTHER PLANTS FROM STOMACH OF OYSTER 5 DAYS AFTER STORM OF AUGUST 13.

PLATE IV

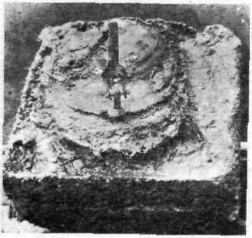

Fig. 1

Fig. 2

FIG. 1. OYSTER 1509 TO SHOW RIVET AND UNIVERSAL JOINT.

FIG. 2. OYSTER 1506, ON THE LEFT, AND OYSTER 1509, ON THE RIGHT, SHOW ING METHOD OF IMBEDDING, RIVET FIXATION AND COPPER TAGS.

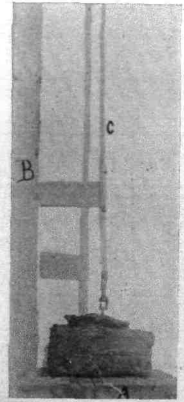

FIG. 3. OYSTER 1509 READY FOR POSITION IN CREEK; A, PLATFORM TO HOI OYSTER AND BLOCK. B, CONNECTING BEAM FROM PLATFORM TO INSTRU MENT HOUSE ABOVE; C, GLASS TUBE ENCLOSING FINE GLASS CONNEC ING ROD FROM OYSTER TO INSTRUMENTS ABOVE.

PLATE V

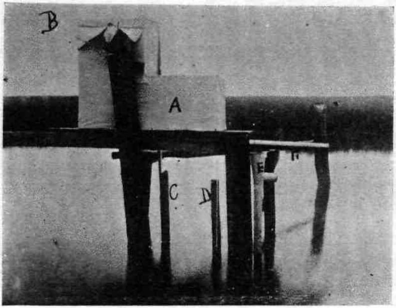

FIG. 1. COMPLETE APPARATUS WITH OYSTER IN POSITION ON BOTTOM OF CREEK. A, INSTRUMENT HOUSE. B, WIRES LEADING TO LABORATORY. C, CONNECTING ROD FROM OYSTER TO INSTRUMENTS. D, TIDE GAUGE. E, BILGE PUMP FOR BOTTOM SAMPLES. F, OBSERVATION PLATFORM.

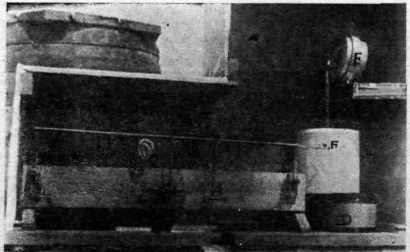

FIG. 2. RECORDING INSTRUMENTS WITHIN HOUSE. A, CONNECTING ROD FROM OYSTER BELOW. B, AND B', MERCURY ELECTRICAL CONTACTS. C, COUNTER WEIGHT FOR BALANCING ENTIRE APPARATUS. D, CHIMOGRAPH WITH REVOLVING DRUM. E, BIG BEN ALARM CLOCK WITH COGS ATTACHED TO MINUTE HAND. F, INKING PEN FOR TRACING RECORD ON DRUM.

REPORT OF THE DEPARTMENT OF SOIL CHEMISTRY AND BACTERIOLOGY

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Report of the Department of Soil Chemistry and Bacteriology

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THE INFLUENCE OF THE MECHANICAL COMPOSITION OF THE SOIL ON THE AVAILABILITY OF NITRATE OF SODA AND DRIED BLOOD

The experiment was planned to determine the relative availability of nitrate nitrogen and organic nitrogen when the two are used in soils varying in mechanical composition. The work is being continued over a period of years in order that data may be accumulated with reference to the residual effects of these fertilizer materials. Barley has been grown for the first crop and with one exception, buckwheat for the second crop. The crop is harvested at maturity and grain and straw saved together and reported as dry matter.

Figure 1 indicates the arrangement of the cylinders with reference to the various dilutions, and the nitrogen treatments for the different series.

All cylinders receive 20 gm. of acid phosphate, 5 gm. of muriate of potash, 5 gm. of sulfate of potash, 38 gm. of ground limestone and 2 gm. of magnesium carbonate, annually, at the time of planting the first crop. The nitrogenous fertilizers also are applied at this time. No additional fertilizer application is made for the second crop, which is planted immediately after the first crop is harvested.

Barley, 1919

Following the residual crop of buckwheat in 1918 the cylinders were seeded to a cover crop of rye. The rye made fair growth during the early spring of 1919 and was 2 to 6 inches high at the time it was turned under on April 8. The rye was best on the loam-soil cylinders and those containing the higher percentages of loam-soil.

The ground was then prepared, fertilizers applied as already indicated and beardless barley planted in each cylinder. A fair crop was harvested July 5, and this was dried, the weights recorded and samples prepared for analysis. The analytical results are presented in table 1.

Series	Arrangement of Cylinders	Soil	*Fertilizer Treatment*
A....	1 2 3 4 5 6	Shale Soil	1, 2, Nothing. 3, 4, 10 gm. nitrate soda. 5, 6, dried blood equivalent to 10 gm. nitrate of soda.
B....	1 2 3 4 5 6	10% sand	"
C....	1 2 3 4 5 6	20% "	"
D....	1 2 3 4 5 6	30% "	"
E....	1 2 3 4 5 6	40% "	"
F....	1 2 3 4 5 6	50% "	"
G....	1 2 3 4 5 6	70% "	"
H....	1 2 3 4 5 6	80% "	"
I....	1 2 3 4 5 6	90% "	"
J....	1 2 3 4 5 6	100% "	"

Fig. 1. Plan of Experiment.

TABLE 1

FIRST CROP, BARLEY, 1919

Series		Nitrogen Applied	Dry Matter: Per Cylinder	Dry Matter: Average	Nitrogen	Nitrogen: Per Cylinder	Nitrogen: Average	Nitrogen: Increase Over Check	Nitrogen Recovered	Relative Availability
		gm.	gm.	gm.	per cent	gm.	gm.	gm.	per cent	
A	1	....	46.0	....	1.129	0.519	....	....	....	....
	2	Nothing	35.2	40.60	1.209	0.426	0.472	....	....	....
	3	1.54	116.5	....	1.129	1.315	....	....	....	....
	4	....	116.0	116.25	1.077	1.249	1.282	0.810	52.59	100.00
	5	....	93.7	....	1.216	1.139	....	....	....	....
	6	1.54	86.4	90.05	1.228	1.061	1.100	0.628	40.78	77.54
B	1	....	49.2	....	1.307	0.643	....	....	....	....
	2	Nothing	33.5	41.35	1.156	0.387	0.515	....	....	....
	3	....	96.6	....	1.176	1.136	....	....	....	....
	4	1.54	117.2	106.90	0.998	1.170	1.158	0.643	41.75	100.00
	5	....	85.2	....	1.137	0.969	....	....	....	....
	6	1.54	85.2	85.20	0.840	0.716	0.842	0.327	21.23	50.86
C	1	....	30.8	....	1.188	0.366	....	....	....	....
	2	Nothing	24.6	27.70	1.275	0.314	0.340	....	....	....
	3	....	114.6	....	1.010	1.157	....	....	....	....
	4	1.54	109.0	111.80	1.069	1.165	1.161	0.821	53.31	100.00
	5	....	81.8	....	1.137	0.930	....	....	....	....
	6	1.54	79.8	80.80	1.109	0.885	0.907	0.567	36.83	69.06
D	1	....	31.7	....	1.208	0.383	....	....	....	....
	2	Nothing	38.0	34.85	1.168	0.444	0.413	....	....	....
	3	....	118.8	....	1.156	1.373	....	....	....	....
	4	1.54	117.2	118.00	1.069	1.253	1.313	0.900	58.44	100.00
	5	....	76.6	....	1.137	0.871	....	....	....	....
	6	1.54	92.0	84.30	1.176	1.082	0.976	0.563	36.56	62.56
E	1	....	13.4	....	1.295	0.174	....	....	....	....
	2	Nothing	29.7	21.55	1.196	0.355	0.264	....	....	....
	3	....	107.6	....	1.196	1.287	....	....	....	....
	4	1.54	106.2	106.90	1.176	1.249	1.268	1.004	65.19	100.00
	5	....	86.0	....	1.109	0.954	....	....	....	....
	6	1.54	82.7	84.35	1.168	0.966	0.960	0.696	45.19	69.32

TABLE 1—(*Continued*)

FIRST CROP, BARLEY, 1919

Series		Nitrogen Applied	Dry Matter: Per Cylinder	Dry Matter: Average	Nitrogen	Nitrogen: Per Cylinder	Nitrogen: Average	Nitrogen: Increase Over Check	Nitrogen Recovered	Relative Availability
		gm.	gm.	gm.	per cent	gm.	gm.	gm.	per cent	
F	1	....	24.2	....	1.156	0.280	....	....	....	....
	2	Nothing	30.6	27.40	1.295	0.396	0.338	....	....	....
	3	....	109.7	....	1.156	1.268	....	....	....	....
	4	1.54	63.5	86.60	1.148	0.729	0.998	0.660	42.86	100.00
	5	....	79.5	....	1.275	1.014	....	....	....	....
	6	1.54	84.0	81.75	1.038	0.872	0.943	0.605	39.28	91.67
G	1	....	19.7	....	1.057	0.208	....	....	....	....
	2	Nothing	22.2	20.95	1.188	0.264	0.236	....	....	....
	3	....	103.5	....	1.307	1.353	....	....	....	....
	4	1.54	88.2	95.85	1.010	0.891	1.122	0.886	57.53	100.00
	5	....	64.6	....	1.137	0.735	....	....	....	....
	6	1.54	63.7	64.15	1.129	0.719	0.727	0.491	31.88	55.41
H	1	....	22.7	....	1.188	0.270	....	....	....	....
	2	Nothing	18.5	20.60	1.188	0.220	0.245	....	....	....
	3	....	79.1	....	1.197	0.947	....	....	....	....
	4	1.54	99.2	89.15	1.216	1.206	1.076	0.831	53.96	100.00
	5	....	75.0	....	1.188	0.891	....	....	....	....
	6	1.54	65.0	70.00	1.228	0.708	0.844	0.599	38.90	72.08
I	1	....	13.3	....	1.129	0.150	....	....	....	....
	2	Nothing	18.4	15.85	1.148	0.211	0.180	....	....	....
	3	....	67.5	....	1.156	0.780	....	....	....	....
	4	1.54	51.8	59.65	1.137	0.589	0.684	0.504	32.73	100.00
	5	....	49.0	....	1.069	0.524	....	....	....	....
	6	1.54	47.5	48.25	1.069	0.508	0.516	0.336	21.82	66.67
J	1	....	7.5	....	1.168	0.088	....	....	....	....
	2	Nothing	5.5	6.50	1.215	0.067	0.077	....	....	....
	3	....	14.0	....	1.453	0.203	....	....	....	....
	4	1.54	12.1	13.05	1.366	0.165	0.184	0.107	6.95	100.00
	5	....	42.7	....	1.188	0.507	....	....	....	....
	6	1.54	28.0	35.35	1.089	0.305	0.406	0.329	21.36	307.34
AVERAGE			Check	25.74	1.193	0.308	....		....	....
			$NaNO_3$ . .	90.41	1.161	1.025	....	0.717	46.53	....
			Dr. Blood.	72.42	1.133	0.822	....	0.514	33.38	....

As in previous years, a larger crop was secured with nitrate of soda as a source of nitrogen than with dried blood in all series except the pure sand series. The highest average yield with the nitrate was secured in the 30 per cent sand series, and this was followed closely by the loam soil and the 20 per cent sand series. For convenience of comparison the average yields of barley (dry matter) for the three treatments, covering the last 5 years are reported in table 2.

TABLE 2.

AVERAGE YIELD OF BARLEY (DRY MATTER) 1915-1919

	1915	1916	1917*	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	28.8	27.6	37.2	37.5	25.7
Nitrate of Soda ...	104.9	127.5	134.1	138.3	90.4
Dried Blood	87.7	94.0	83.1	92.9	72.4

It is significant that with 40 per cent sand the yield on the nitrate cylinders is only about 10 gm. less than the yield on the loam soil. With 90 per cent sand the yield is only about half as much as was obtained on the corresponding cylinders with 40 per cent sand.

Percentage of Nitrogen in Dry Matter and Total Nitrogen Recovered

Slight differences are noted in the percentage of nitrogen in the dry matter, but these are not especially significant.

The total yield of nitrogen usually varies with the yield of dry matter. It sometimes happens, however, that a low yield of dry matter shows a high percentage of nitrogen. This is true of series J, where there was an average yield of 13 gm. of dry matter showing 1.45 and 1.37 per cent of nitrogen in the two samples. The total yield of nitrogen recovered under the three treatments for the years 1915 to 1919 is shown in table 3.

The check cylinder gives, on an average, a yield of 0.3 to 0.4 gm., the nitrate of soda cylinder a yield of 1 gm. to 1.3 gm., and the dried-blood cylinder a yield of 0.8 to about 1.0 gm.

Percentage of Nitrogen Recovered

In calculating the percentage of nitrogen recovered it is assumed that the difference between the amount of nitrogen found in the crops from the check cylinders and that from the nitrogen-treated cylinders represents the amount of nitrogen which the latter were able to secure from the applied fertilizers. In practice this can be only approximately correct, but it serves as a method of comparing the amount of nitrogen which the crop is able to win back when different materials are used.

TABLE 3

YIELD OF NITROGEN, 1915-1919

	1915	1916	1917	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	0.311	0.318	0.412	0.404	0.308
Nitrate of Soda ...	1.156	1.252	1.344	1.234	1.025
Dried Blood	0.977	0.953	0.889	0.927	0.822

From an application of 1.54 gm. of nitrogen in the form of nitrate of soda and dried blood, the amount that was recovered in the barley for the ten series has been calculated. These figures are shown in the column, "Per cent of Nitrogen recovered," table 1.

For nitrate of soda a recovery of 65.19 per cent was obtained with the 40 per cent sand mixture, and 58.44 per cent with the 30 per cent sand mixture. The lowest recovery from nitrate of soda was 6.95 per cent in the all-sand cylinders.

In this connection it may be pointed out that this is the only case where the recovery from blood exceeded the recovery from nitrate of soda.

The highest recovery from dried blood was 45.19 per cent, also with the 40 per cent sand mixture, and the lowest 21.36 per cent with sand. The average recovery from nitrate of soda was 46.53 per cent and from dried blood 33.38 per cent.

The average recoveries for the last 5 years are shown in table 4.

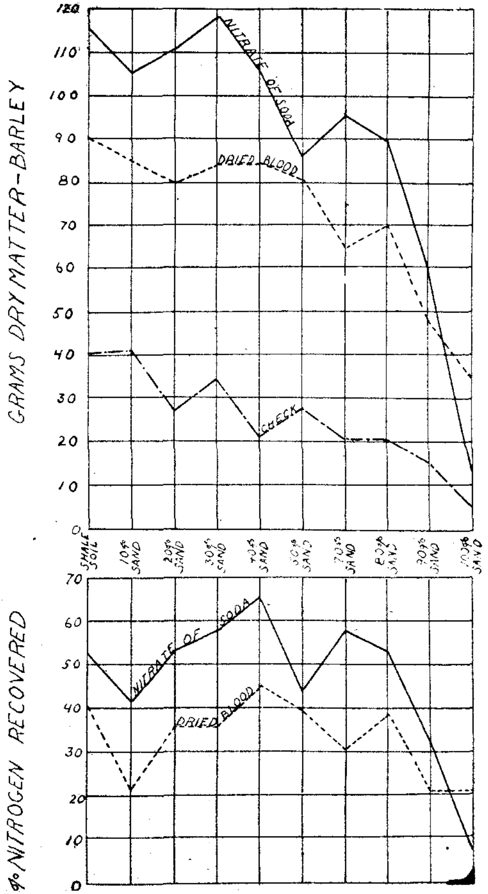

FIG. 2. CURVES SHOWING WEIGHT OF DRY MATTER AND PERCENTAGE OF NITROGEN RECOVERED IN FIRST CROP—BARLEY, 1919

The figures expressing the relative availability of the two materials are shown in the last columns of table 1.

If we take 100 as representing the availability of nitrate of soda, then the availability of dried blood for the loam soil will be 77.54; in the same way the relative availability of blood with the 50 per cent sand loam-soil mixture is 91.67, and for the all-sand series it is 307.34.

Thus it is shown that for the loam-soil and for all dilutions of this soil up to and including 90 per cent sand, nitrate of soda has a higher availability than dried blood. In the all-sand series the blood shows more lasting properties than the nitrate.

The yield of dry matter (barley) and the percentage of nitrogen recovered are indicated by graphs in figure 2.

TABLE 4

AVERAGE RECOVERY OF NITROGEN FROM NITRATE OF SODA AND DRIED BLOOD, 1915-1919

	1915	1916	1917	1918	1919
	per cent	per cent	per cent	per cent	per cent
Nitrate of Soda ...	54.89	60.64	60.53	53.90	46.53
Dried Blood	43.28	41.23	30.98	33.97	33.38

Buckwheat-Residual Crop, 1919

Buckwheat is seeded as a second crop in order that any nitrogen which the first crop may have left may be used. No fertilizers are applied for this second crop.

The buckwheat was seeded July 12, about two days after the barley was harvested. On the sixteenth the grain was coming up uniformly in all cylinders. Growth was normal and on September 9 the crop was harvested and samples saved and prepared for analysis in the usual way. The analytical results together with a summary for the two crops are reported in table 5.

TABLE 5

Residual Crop of Buckwheat, 1919, and Summary for Both Crops

Series			Dry Matter: Per Cylinder	Dry Matter: Average	Nitrogen	Nitrogen: Per Cylinder	Nitrogen: Average	Increase Over Check	Nitrogen Recovered	Summary for Both Crops: Total Dry Matter	Summary for Both Crops: Total Nitrogen	Summary for Both Crops: Nitrogen Increase Over Check	Summary for Both Crops: Nitrogen Recovered	Summary for Both Crops: Relative …
			gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	
A	NO NITROGEN APPLIED FOR RESIDUAL CROP	1	33.0	.....	0.845	.279	.....	.....	.....	.....	.....	.....	.....	....
		2	39.1	36.05	1.133	.443	.3610	.....	.....	76.65	.8330	.....	.....	....
		3	37.5	.....	0.949	.356	.....	.....	.....	.....	.....	.....	.....	....
		4	34.5	36.00	1.133	.391	.3735	.0125	0.81	152.25	1.6555	0.8225	53.41	100.
		5	58.3	.....	1.114	.649	.....	.....	.....	.....	.....	.....	.....	....
		6	52.3	55.30	1.056	.552	.6005	.2395	15.55	145.35	1.7005	0.8675	56.33	105.
B		1	45.5	.....	1.123	.511	.....	.....	.....	.....	.....	.....	.....	....
		2	36.0	40.75	1.114	.401	.4560	.....	.....	82.10	.9710	.....	.....	....
		3	36.0	.....	1.160	.418	.....	.....	.....	.....	.....	.....	.....	....
		4	50.6	43.30	1.210	.612	.5150	.0590	3.83	150.20	1.6730	0.7020	45.59	100.
		5	42.2	.....	1.075	.454	.....	.....	.....	.....	.....	.....	.....	....
		6	50.7	46.45	1.114	.565	.5095	.0535	3.47	131.65	1.3515	0.3805	24.71	54.
C		1	33.7	.....	1.152	.388	.....	.....	.....	.....	.....	.....	.....	....
		2	36.3	35.00	1.172	.425	.4065	.....	.....	62.70	.7465	.....	.....	....
		3	40.5	.....	1.114	.451	.....	.....	.....	.....	.....	.....	.....	....
		4	44.7	42.60	1.160	.519	.4850	.0785	5.10	154.40	1.6460	0.8995	58.47	100.
		5	34.5	.....	1.152	.397	.....	.....	.....	.....	.....	.....	.....	....
		6	45.3	39.90	1.152	.522	.4595	.0530	3.44	120.70	1.3665	0.6200	40.26	68.
D		1	32.0	.....	1.179	.377	.....	.....	.....	.....	.....	.....	.....	....
		2	35.8	33.90	1.198	.429	.4030	.....	.....	68.75	.8160	.....	.....	....
		3	40.5	.....	1.123	.455	.....	.....	.....	.....	.....	.....	.....	....
		4	47.0	43.75	1.191	.560	.5075	.1045	6.79	161.75	1.8205	1.0045	65.23	100.
		5	38.2	.....	1.152	.440	.....	.....	.....	.....	.....	.....	.....	....
		6	49.7	43.95	1.114	.554	.4970	.0940	6.10	128.25	1.4730	0.6570	42.66	65.
E		1	40.2	.....	1.275	.513	.....	.....	.....	.....	.....	.....	.....	....
		2	33.5	36.85	1.133	.380	.4465	.....	.....	58.40	.7105	.....	.....	....
		3	37.4	.....	1.248	.467	.....	.....	.....	.....	.....	.....	.....	....
		4	39.5	38.45	1.248	.493	.4800	.0335	2.18	145.35	1.7480	1.0375	67.37	100.
		5	40.5	.....	1.172	.475	.....	.....	.....	.....	.....	.....	.....	....
		6	36.7	38.60	1.287	.472	.4735	.0270	1.75	122.95	1.4335	0.7230	46.95	69.

TABLE 5—(Continued)

Residual Crop of Buckwheat, 1919, and Summary for Both Crops

NO NITROGEN APPLIED FOR RESIDUAL CROP

Series		Dry Matter: Per Cylinder	Dry Matter: Average	Nitrogen	Nitrogen: Per Cylinder	Nitrogen: Average	Increase Over Check	Nitrogen Recovered	Summary for Both Crops: Total Dry Matter	Summary for Both Crops: Total Nitrogen	Summary for Both Crops: Nitrogen Increase Over Check	Summary for Both Crops: Nitrogen Recovered	Summary for Both Crops: Relative Availability
		gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	
F	1	45.5		1.114	.507								
	2	36.2	40.85	1.248	.452	.4795			68.25	.8175			
	3	28.0		1.191	.333								
	4	42.2	35.10	1.210	.511	.4220			121.70	1.4200	0.6025	39.12	100.00
	5	39.7		1.198	.476								
	6	34.7	37.20	1.123	.390	.4330			118.95	1.3760	0.5585	36.27	92.70
G	1	22.5		1.191	.268								
	2	21.0	21.75	1.268	.266	.2670			42.70	.5030			
	3	24.7		1.191	.294								
	4	34.2	29.45	1.248	.427	.3605	.0935	6.07	125.30	1.4825	0.9795	63.60	100.00
	5	30.5		1.191	.363								
	6	17.4	23.95	1.218	.212	.2875	.0205	1.33	88.10	1.0145	0.5115	33.21	52.22
H	1	19.9		1.160	.231								
	2	17.0	18.45	1.218	.207	.2190			39.05	.4640			
	3	9.0		1.160	.104								
	4	17.5	13.25	1.306	.229	.1665			102.40	1.2425	0.7785	50.57	100.00
	5	18.0		1.218	.219								
	6	14.3	16.15	1.191	.170	.1945			86.15	1.0385	0.5745	37.31	73.80
I	1	4.0		1.256	.050								
	2	7.2	5.60	1.287	.093	.0715			21.45	.2515			
	3	6.5		1.248	.081								
	4	7.0	6.75	1.314	.092	.0865	.0150	0.97	66.40	.7705	0.5190	33.70	100.00
	5	27.0		1.371	.233								
	6	15.5	16.25	1.371	.213	.2230	.1515	9.80	64.50	.7390	0.4875	31.66	93.95
J	1	2.0		1.498	.030								
	2	3.2	2.60	1.421	.045	.0375			9.10	.1145			
	3	2.5		1.506	.037								
	4	1.5	2.00	1.325	.020	.0285			15.05	.2125	0.0980	6.36	100.00
	5	10.0		1.371	.137								
	6	5.0	7.50	1.867	.093	.1150	.0775	5.03	42.85	.5210	0.4065	26.40	414.80
AVERAGE	1		27.18	1.199		.3148			52.92	0.6228			
	2												
	3		29.07	1.211		.3425			119.48	1.3671	.7444	48.34	
	4												
	5		32.53	1.225		.3793			104.95	1.2014	.5787	37.58	
	6												

From this table it will be observed that in the majority of cases the yield was larger with dried blood than with nitrate of soda. This is an indication that the nitrate was more completely used by the first crop than the blood; or to state the matter another way, the blood has greater residual effects than the nitrate. The yields are shown by graphs in figure 3.

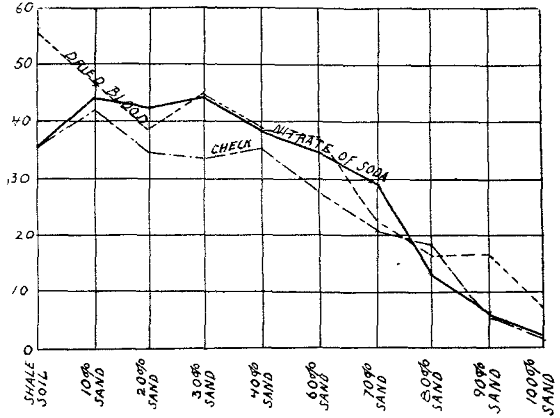

FIG. 3. CURVES SHOWING GRAMS OF DRY MATTER IN SECOND CROP—BUCKWHEAT, 1919

This greater residual effect is not sufficient, however, to offset the initial effect of the nitrate on the first crop and, as has been pointed out in previous reports, this greater initial influence of the nitrate serves to place it in the first rank when the two crops are considered together. This is shown in the last part of table 5.

The average yields for the residual crops for the five years, 1915-1919, are shown in table 6.

TABLE 6

AVERAGE YIELD OF BUCKWHEAT-RESIDUAL CROP, 1915-1919

	1915*	1916	1917	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	21.32	25.83	32.31	32.0	27.18
Nitrate of Soda ..	22.58	23.78	32.70	29.0	29.07
Dried Blood	28.22	32.70	44.24	45.1	32.53

* *Kafir Corn.*

It is of interest to compare these figures with the figures showing the combined yields of the two crops for the same period. These are shown in table 7.

TABLE 7

COMBINED YIELDS OF BARLEY AND BUCKWHEAT (DRY MATTER), 1915-1919

	1915	1916	1917	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	50.11	53.45	68.92	69.62	52.92
Nitrate of Soda ..	127.44	151.30	166.79	167.33	119.48
Dried Blood	115.90	126.70	124.75	138.04	104.95

This table emphasizes what has already been mentioned, namely, that when the two crops are combined the yield with nitrate of soda exceeds the yield with dried blood, even though equivalent amounts of nitrogen are used. The greater effectiveness of the nitrate during the early life of the plant has been suggested as an explanation for this pronounced difference. The rapid development of the nitrate-treated plants, with large, well-filled heads and broad leaves, suggests this explanation. Figures 4, 5 and 6 show graphically the comparative yields of the two crops on the shale soil, the 40 per cent sand mixture, and the 80 per cent sand mixture, with nitrate of soda, dried blood and no nitrogen (check), for the years 1912-1919.

It will be noted that for the shale soil the yield with dried blood exceeds the yield with nitrate of soda in three out of the eight years; for the 40 per cent sand mixture the yield with nitrate of soda exceeds the yield with blood throughout the eight years; for the 80 per cent sand mixture the yield with blood exceeds the yield with nitrate in two out of the eight years. It is significant that the yield for the 80 per cent sand mixture should so consistently run higher with nitrate

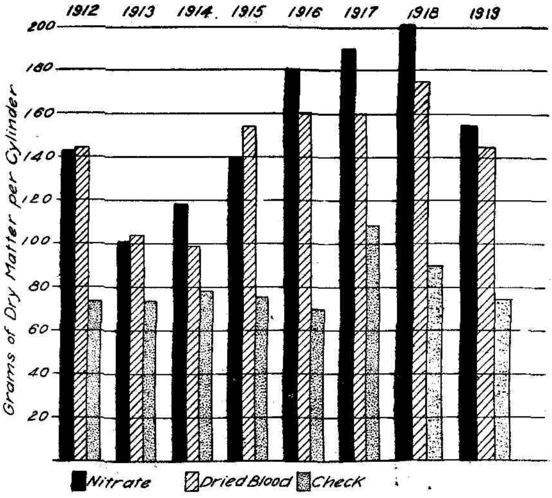

FIG. 4. COMPARATIVE YIELD OF DRY MATTER, TWO CROPS EACH YEAR, FROM SHALE SOIL (PENN LOAM) WITH NITRATE OF SODA, DRIED BLOOD AND CHECK (NO NITROGEN), 1912-1919

than with blood. It would be expected that with such a high percentage of sand the loss of nitrates through leaching would be excessive. It is possible that two factors may combine to reduce this loss; the barley, once it is well-started, makes a rapid growth and thus uses the nitrates rapidly, and the second crop, which is always grown, helps to conserve any available nitrogen not utilized by the first crop.

These results indicate that in some cases, at least, the ease with which nitrates are lost has been over-emphasized.

Percentage of Nitrogen Recovered-Residual Crop

The recovery of nitrogen through the residual crop was small. Indeed in some cases there was no recovery above the amount recovered through the crops on the check cylinders—that is, there was no recovery from applied fertilizers. In series B, C, D, E and G the recovery with *nitrate* was greater than with dried blood. This is the reverse of what has usually been true for the residual crop. The highest recovery for this crop was 15.55 with dried blood, in series A.

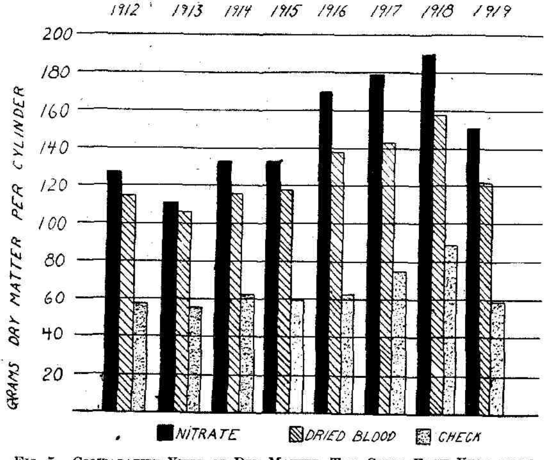

FIG. 5. COMPARATIVE YIELD OF DRY MATTER, TWO CROPS EACH YEAR, FROM THE 40 PER CENT SAND MIXTURE (SERIES E) WITH NITRATE OF SODA, DRIED BLOOD AND CHECK, 1912-1919

Summary

When barley was grown on loam soil and on various dilutions of this loam with sand, nitrate of soda gave a larger yield of dry matter and a higher percentage of nitrogen recovered, than an equivalent *amount of dried blood, in all cases except the all-sand series.*

The average recovery with nitrate, for all series, was 46.53 per cent, and for dried blood 33.38 per cent.

The average for the past five years is: nitrate of soda, 55.3 per cent; dried blood, 36.6 per cent.

With the residual crop—buckwheat—grown without any further fertilizer treatment, there was very little recovery of nitrogen from either nitrate of soda or dried blood.

When the results for the two crops are combined the average recoveries stand:

Nitrate of Soda	47.34 per cent
Dried Blood	37.58 per cent

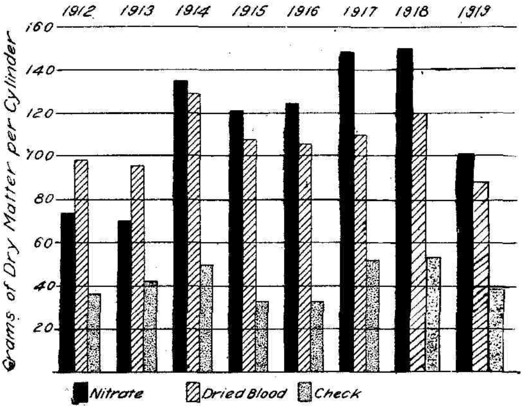

FIG. 6. COMPARATIVE YIELDS OF DRY MATTER, TWO CROPS EACH YEAR, FROM THE 80 PER CENT SAND MIXTURE (SERIES H) WITH NITRATE OF SODA, DRIED BLOOD AND CHECK, 1912-1919

The average combined recoveries for the last five years are:

Nitrate of Soda	57.02 per cent
Dried Blood	49.60 per cent

With the soil under consideration, nitrate gives only a slight *residual* recovery of nitrogen, but its *initial* effect—that is the effect on the first crop—is sufficiently above the initial effect of dried blood to give it a higher standing than the latter, when the results for the two crops are combined.

THE INFLUENCE OF LIME ON THE YIELD AND NITROGEN CONTENT OF SOYBEANS

Since 1913 this department has been conducting experiments with different varieties of soybeans on limed and nnlimed plots.

The latest published account of this work appeared in the annual report for 1918. The results for 1918 and 1919 have now been tabulated and are herewith reported.

Plan of Experiment

The experiment is carried out on small plots varying in size from 1-80 to 1-40 acre. The soil is a loam of fair quality, though naturally deficient in nitrogen. To certain of the plots ground limestone was applied in 1908, at the rate of 1 ton per acre. Other plots received no lime. The lime treatment was repeated in 1913 and again in 1918, this time at the rate of 2 tons per acre. All plots receive annual applications of acid phosphate and muriate of potash—the former at the rate of 400 to 600 pounds per acre and the latter at the rate of 100 to 200 pounds per acre. With one exception to be noted hereafter, nitrogenous fertilizers have not been applied. Lime requirement and nitrogen determinations have been made on samples of soil taken from these plots before the lime was applied in the spring of 1918. The results are as follows:

	Lime Requirement (Veitch Method)	Nitrogen
	pounds	per cent
Limed Plots	700	0.1055
Unlimed Plots	1,550	0.0900

It will be noted that the soil from the limed plots shows a higher percentage of nitrogen than that from the unlimed plots. This is in accord with results secured on the same kind of soil when clover was seeded with timothy in a 5-year rotation of corn, oats, wheat, and timothy and clover, and just the opposite of results secured in the same rotation with the omission of the clover.

A record has also been made of the number of nodules found on a definite number of plants taken from limed and unlimed plots, for certain varieties.

The beans are allowed to stand and ripen on the vines and this means that at harvest time practically all leaves have fallen off.

VARIETY	LIMED D'y B'n Bu.	LIMED Nitrogen Per ct.	LIMED Nitrogen Lbs.	UNLIMED D'y B'n Bu.	UNLIMED Nitrogen Per ct.	UNLIMED Nitrogen Lbs.	LIMED D'y St'k Lbs.	LIMED Nitrogen Per ct.	LIMED Nitrogen Lbs.	UNLIMED D'y St'k Lbs.	UNLIMED Nitrogen Per Ct.	UNLIMED Nitrogen Lbs.	Total Nitrogen Recovered Limed Lbs.	Total Nitrogen Recovered Unlimed Lbs.
in	21.3	6.18	79.10	9.6	5.91	34.16	1,720	0.66	11.27	934	0.68	6.38	90.37	40.54
n	20.9	7.46	93.40	11.2	6.52	43.81	1,364	0.96	13.03	760	0.77	5.83	106.43	49.64
erlandt	14.5	6.64	57.90	5.1	6.36	19.33	1,592	1.69	26.90	460	1.61	7.41	84.80	26.74
chu	19.5	6.01	70.20	10.1	5.52	33.34	896	*	......	648	*	......	70.20†	33.34†
hattan	14.1	6.60	55.97	6.1	6.05	22.02	1,040	0.88	9.15	488	0.70	3.43	65.12	25.45
Yellow	20.0	6.06	72.72	11.9	5.54	39.45	1,488	0.83	12.40	848	0.72	6.11	85.12	45.56
9035	17.5	6.45	67.60	7.3	5.86	25.55	1,344	1.33	17.88	764	1.02	7.79	85.48	33.34
inia	20.8	6.26	78.13	10.8	5.77	37.39	1,792	0.79	14.09	904	0.99	8.97	92.22	46.36
Average	18.6	6.46	71.88	9.0	5.94	31.88	1,405	1.00	14.96	726	0.92	6.56	87.08	38.23
d	12.9	7.07	54.58	These varieties were not represented by unlimed plots.			1,470	1.03	15.14	......	......	......	69.72	....
d	19.5	5.94	69.50				1,968	0.62	12.16	......	......	......	81.66	....
ıy	16.8	6.77	68.24				1,236	1.13	13.97	......	......	......	82.21	....
a	20.6	6.34	78.36				1,686	0.70	11.84	......	......	......	90.20	....
ph	16.2	6.25	60.56				1,353	0.85	11.53	......	......	......	72.09	....
San	17.9	6.79	72.79				1,192	*	......	......	......	......	72.79†	....
n. No. 115	18.0	6.50	70.40				1,047	*	......	......	......	......	70.40†	....
n	19.1	6.34	72.78				1,604	1.03	16.52	......	......	......	89.30	....
ion	17.9	6.07	65.13				1,363	*	......	......	......	......	65.13†	....
Average	17.7	6.45	68.04				1,435	0.89	13.53	......	......	......	80.86	....

* Nitrogen not determined.
† For beans only, omitted from average.

Results for 1918

The yields and analytical results for the different varieties are shown in table 8.

From the table it will be noted that in addition to the limed and unlimed series nine varieties were grown on limed plots and were not represented by corresponding unlimed plots.

Shelled Beans

The yield of dry shelled beans on the limed plots varies from about 13 to about 21 bushels, with an average of slightly more than 18 bushels per acre. The unlimed plots show an average of 9 bushels per acre.

The average nitrogen content of the beans from the limed plots is 6.46 per cent (maximum 7.46, minimum 6.01) and the average from the unlimed plots is 5.94 per cent.

The average amount of nitrogen recovered from the limed plots was 71.88 pounds (68.04 for the nine varieties not having corresponding limed plots) and 31.88 pounds for the unlimed plots. The highest individual yield was 93.4 pounds from Elton and the lowest 55.97 pounds from Manhattan.

Dry Stalks

The average yield of dry stalks from the limed plots of the first eight varieties was 1,405 pounds per acre and the average from the unlimed plots 726 pounds. The average nitrogen content of seven of these varieties from the limed plots was 1.00 per cent, and from the unlimed plots 0.92 per cent.

More than twice as much nitrogen was recovered through the stalks from the limed plots as from the unlimed plots.

The average total nitrogen—from beans and stalks—recovered from the limed plots was 87.08 pounds per acre and the average from the *unlimed plots was 38.23 pounds per acre. The highest individual re-*covery was 106.43 pounds from Elton. It should be borne in mind that this does not represent the nitrogen of the leaves and roots.

Results for 1919

The results for 1919 are shown in table 9. They bear out, in a striking manner, the results of the preceding year, and also results secured in 1916 and 1917.

The Influence of Lime on the Yield and Nitrogen Content of Soybeans, 1919 (Calculated to the Acre Basis)

VARIETY	LIMED D'y B'n	LIMED Nitrogen		UNLIMED D'y B'n	UNLIMED Nitrogen		LIMED D'y St'k	LIMED Nitrogen		UNLIMED D'y St'k	UNLIMED Nitrogen		Total Nitrogen Recovered	
	Bu.	Per ct.	Lbs.	Bu.	Per ct.	Lbs.	Lbs.	Per ct.	Lbs.	Lbs.	Per Ct.	Lbs.	Limed Lbs.	Unlimed Lbs.
Baird	14.6	7.01	61.44	3.3	6.77	13.40	1,566	1.294	20.26	414	1.176	4.87	81.70	18.27
Ebony	19.4	6.71	78.07	1.4	6.88	5.78	1,254	0.978	12.26	168	1.085	1.82	90.33	7.60
Edna	22.4	6.36	85.52	0.5	6.29	1.89	1,794	0.868	15.57	210	1.274	2.68	101.09	4.57
Minn. No. 115	13.7	6.45	53.02	4.2	6.32	15.93	1,026	0.848	8.70	396	0.998	3.95	61.72	19.88
Iwan	20.9	6.85	85.85	1.3	6.32	4.93	1,716	1.065	18.28	132	0.888	1.17	104.13	6.10
Wilson	19.5	5.99	70.07	1.1	5.40	3.56	1,656	0.840	13.91	138	0.947	1.31	83.98	4.87
Average	18.4	6.56	72.33	2.0	6.33	7.58	1,502	0.983	14.83	243	1.063	2.63	87.16	10.21
Austin	21.4	6.61	84.65	These varieties were not represented by unlimed plots.			1,428	0.959	13.70	......	......	......	98.35	....
Cloud	16.8	6.19	62.36				1,770	1.262	22.34	......	......	......	84.77	....
Elton	20.6	7.00	86.55				1,224	1.065	13.04	......	......	......	99.59	....
Haberlandt	19.3	6.82	78.94				1,674	1.105	18.50	......	......	......	97.44	....
Hahto	13.5	6.21	50.26				1,602	1.854	29.70	......	......	......	79.96	....
Ito San	11.2	6.77	45.47				918	1.767	16.20	......	......	......	61.67	....
Manchu	24.1	6.42	92.86				1,650	1.203	19.85	......	......	......	112.71	....
Manhattan	5.6*	6.83	22.93*				426*	0.959	4.09*	......	......	......	27.02*	....
Virginia	22.9	6.31	86.73				2,046	0.789	16.14	......	......	......	102.87	....
Average	18.7	6.57	73.48				1,539	1.220	18.68	......	......	......	92.17	....

* Omitted from average.

There is, however, this difference between results for this year and previous years; the unlimed plots are all the time becoming more acid, and on this account there is a marked falling off in the yield from these plots. On some of the plots the crop was almost an entire failure.

The average yield of shelled beans on the limed plots was about 18½ bushels per acre and on the unlimed plots only 2 bushels per acre. The average nitrogen content on the limed plots was 6.56 per cent and the average on the unlimed plots 6.33 per cent. Of the 6 varieties grown on limed and unlimed plots five show a higher percentage of nitrogen when grown on the limed plots than when grown on the unlimed plots. The average nitrogen recovered from the six limed plots was 72.33 pounds per acre as against 7.58 pounds for the corresponding unlimed plots. The figures for the nine varieties grown on limed plots only, check very closely with the figures for the limed section of the six varieties just considered.

Dry Stalks

The average yield of dry stalks from the limed section of the first six varieties was 1,502 pounds per acre and the average from the corresponding unlimed section 243 pounds. In this case the average percentage of nitrogen in samples from the unlimed section is slightly higher than the average in samples from the limed section. The average nitrogen recovered in the stalks stands 14.83 pounds per acre from the limed section and 2.63 pounds from the unlimed section.

The average total nitrogen recovered through beans and stalks is, for the limed section 87.16 pounds per acre and for the unlimed section 10.21 pounds. The average yield of nitrogen for the 9 varieties not having corresponding nnlimed plots is 92.17 pounds per acre. It is thus shown there was nearly nine times as much nitrogen recovered through beans grown on limed plots as through those grown on unlimed plots.

Plate 1 shows Virginia soybeans grown on limed and unlimed plots in 1918. The yields from this variety are given in tables 8 and 9. Plate 2 shows beans growing on limed and unlimed plots in 1919. These two plots lie side by side and three varieties were grown on each plot. The photographs were made from the same relative position with reference to the three varieties.

The Influence of Lime on Nodule Formation

Note has been made in previous reports of the difference in the number of nodules on the roots of soybean plants grown on limed and unlimed plots. During the summer of 1919 fnrther results were secured on this point and they are given here as confirming the earlier work.

When the plants were just coming into bloom twelve representative plants were removed from the limed and unlimed sections of the three plots on which the Baird, Swan and Wilson varieties had been planted. In removing the plants, care was taken to save as many of the nodules as possible. The nodules were counted and the tops and roots separated and dried. After drying, the samples were ground and analyzed for nitrogen. The results are shown in table 10.

TABLE 10

INFLUENCE OF LIME ON NODULE FORMATION

	DRY TOPS		DRY ROOTS			
	Nitrogen		Nitrogen		Number of Nodules per plant	
	Limed per cent	Unlimed per cent	Limed per cent	Unlimed per cent	Limed	Unlimed
Baird	3.83	3.60	2.08	1.83	106	16
Swan	3.75	3.25	1.60	1.53	129	3
Wilson	3.35	3.17	1.77	1.77	97	6

With reference to the tops it will be noted that without exception the samples from the limed plots show a higher percentage of nitrogen than those from the unlimed plots.

For the roots this is true for two of the varieties while for the third variety—Wilson—the percentage is the same for the limed and the unlimed sections. The plants on the unlimed section made a stunted growth and produced but few nodules, while those on the limed plots made a healthy growth and were abundantly supplied with nodules. The average number of nodules per plant for the latter was 110 and for the former was only 8 1-3.

It is of interest to note the high percentage of nitrogen in the tops from the limed section. Two tons of soybean hay analyzing as high as the sample represented by the Baird would mean more than 150 pounds of nitrogen per acre, exclusive of roots.

It is very evident that there is a close relationship between the reaction of the soil and the development of those organisms which cause nodule formation, and therefore between the reaction of the soil and nitrogen accumulation.

Summary

Several varieties of soybeans have been grown on limed and unlimed plots continuously since 1913.

The average yield on the limed plots for the seasons of 1918 and 1919 was a little over 18 bushels of shelled beans per acre. For the unlimed plots the average for 1918 was 9 bushels per acre and for 1919 only 2 bushels per acre.

The maximum yield for the limed plots was slightly over 21 bushels per acre in 1918 and nearly 23 bushels in 1919.

The average yield of dry stalks for the limed plots was close to ¾ ton per acre for both years, whereas the average yield for the unlimed plots was 726 pounds in 1918 and only 243 pounds in 1919.

The average percentage of nitrogen in the dry shelled beans was as follows:

	1918 per cent	1919 per cent
Limed	6.46	6.56
Unlimed	5.94	6.33

For both years the limed plots of the section having both limed and unlimed plots gave an average return of 87 pounds of nitrogen per acre exclusive of the nitrogen in roots and fallen leaves. The unlimed plots gave an average return of 38.2 pounds per acre in 1918 and 10.2 pounds in 1919.

When plants were taken up by the roots about the time they were beginning to bloom, there were, on the average, more than ten times as many nodules on plants from limed as from unlimed plots. These plants from the limed plots—both tops and roots—contained a higher percentage of nitrogen than plants from the corresponding unlimed plots.

Lime aids greatly in the accumulation of nitrogen through the use of leguminous plants.

THE INFLUENCE OF NITROGENOUS FERTILIZERS ON THE YIELD AND NITROGEN CONTENT OF SOYBEANS

It is generally believed that when leguminous crops are grown on properly inoculated soil that is not acid, they do not require nitrogeneous fertilizers.

TABLE 11

The Influence of a Nitrogenous Fertilizer on the Yield and Nitrogen Content of Soybeans

Fertilizer Treatment	Shelled Beans			Stalks			Total Nitrogen
	Beans	Nitrogen		Dry Matter	Nitrogen		
	bushels	per cent	pounds	pounds[1]	per cent	pounds	pounds
Ohio 9035—							
Nitrate of Soda	16.6	6.371	63.46	1068	1.578	16.85	80.31
Ammonium Sulfate	15.4	6.509	60.15	1038	1.124	11.67	71.82
No Nitrogen (check)	18.2	6.608	72.16	1296	1.282	16.62	88.78
Medium Yellow—							
Nitrate of Soda	22.7	6.186	84.25	1638	0.986	16.51	100.76
Calcium Cyanamid..	22.6	6.344	86.03	1614	0.927	14.96	100.99
No Nitrogen (check)	21.5	6.320	81.53	1488	1.144	17.03	98.56

In connection with the soybean experiments it seemed worth while to try out three nitrogenous materials to determine whether their use, might in any way influence the yield or the nitrogen content of the dry matter.

The soil is the same as that described in the preceding report, and the lime, phosphate and potash treatment has been the same as that given the limed soybean plots already described.

The nitrogenous fertilizers were applied in the row, before planting, at the rate of 150 pounds of nitrate of soda per acre, and equivalent amounts of the ammonium sulfate and calcium cyanamid.

Two varieties of beans were planted; Ohio 9,035 on three plots, the treatments for which were nitrate of soda, ammonium sulfate and the check, or no nitrogen; and Medium Yellow on three other plots, the treatments for which were nitrate of soda, calcium cyanamid, and the check. The results of the test are given in table 11.

For Ohio 9035 the no-nitrogen plot gave the highest yield of beans and stalks and also the highest percentage of nitrogen in the shelled beans. From the check plot of this series there was recovered 88.78 pounds of nitrogen per acre, whereas from the nitrate of soda and ammonium sulfate plots the recoveries were 80.31 pounds and 71.82 pounds per acre, respectively.

For the Medium Yellow variety the yield of shelled beans on the check plot was slightly over 1 bushel per acre less than the yield on the two nitrogen-treated plots, but the percentage of nitrogen in the dry matter was sufficiently well maintained to bring the total nitrogen recovered to within about 2½ pounds of the amount recovered in the two nitrogen-treated plots. It is of interest to note that the average recovery of nitrogen through the crop on the three plots occupied by the Medium Yellow is 100 pounds per acre.

The work further confirms the general belief that legume crops, when properly inoculated, do not require nitrogenous fertilizers.

THE CONTINUOUS GROWING OF CORN WITH A LEGUME AND A NON-LEGUME GREEN MANURE CROP, 1919

This constitutes the twelfth report on this work. The results for the years 1908 to 1918 have appeared in earlier reports of the station. In this experiment a study is being made of the value of a legume green-manure crop as compared with a non-legume in the continuous growing of corn. On each section small amounts of cow manure are used for the purpose of inocnlating the soil with decay organisms.

The soil is a gravelly loam which is deficient in nitrogen.

Plan of Experiment

The plots are 1-20 acre in size. Ground limestone was applied in 1908 when the work was started, and again in 1913 and 1918. Before planting the corn in 1919 acid phosphate and muriate of potash were applied broadcast at the rate of 300 and 100 pounds per acre, respectively. Nitrate of soda and ammonium sulfate also were applied, the combined application being equivalent to 160 pounds of nitrate of soda per acre. The special treatment for the two sections was as follows:

Legume Section

Plot 49—Corn followed by legume cover crop, no manure
Plot 50—Corn followed by legume cover crop, 50 pounds of manure
Plot 51—Corn followed by legume cover crop, 100 pounds of manure
Plot 52—Corn followed by legume cover crop, 200 pounds of manure

Non-Legume Section

Plot 53—Corn followed by non-legume cover crop, no manure
Plot 54—Corn followed by non-legume cover crop, 50 pounds of manure
Plot 55—Corn followed by non-legume cover crop, 100 pounds of manure
Plot 56—Corn followed by non-legume cover crop, 200 pounds of manure

The manure is spread evenly over the land before it is plowed in the spring. The quantity of manure is purposely small in order that the fertilizing effects may be kept to the minimum.

Crop of 1919

About the last of July, 1918, a mixture of vetch, alfalfa, and red and alsike clover was seeded in plots 49-52, and about the middle of October, after the corn had been cut, rye was seeded in plots 53-56. (The blowing over of the corn by storms prevented earlier seeding on these plots.)

On May 3, 1919, it was noted that there was a fair covering of vetch and clovers on plots 49-52, and a thin stand of rye, about 18 inches high, on plots 53-56.

Manure was applied to the plots in accordance with the plan and they were plowed and prepared for planting. Corn was planted on May 15. A good stand was secured and the crop was given the usual care in the way of cultivation. In August the cover crops were seeded —for the legume section a mixture of vetch and red and white sweet clover; and rye for the non-legume section.

On September 19 the corn was harvested and shocked and after the usual drying in the shock it was husked and samples prepared and dried. The analytical results are shown in table 12.

TABLE 12

Continuous Corn with Legume and Non-Legume Green Manure Crop—1919
(Calculated to the acre basis)

Plot Number	SPECIAL TREATMENT (per plot)	GRAIN			STALKS			COBS				INCREASE OVER CHECK PLOT		
		Dry Grain Bushels	Per Cent Nitrogen	Nitrogen Pounds	Dry Stalks Pounds	Per Cent Nitrogen	Nitrogen Pounds	Dry Cobs Pounds	Per Cent Nitrogen	Nitrogen Pounds	Total Nitrogen Pounds	Grain Bushels	Stalks and Cobs Pounds	Nitrogen Pounds
	LEGUME SECTION													
49	No manure	30.4	1.479	25.14	2524	.879	22.19	380	.373	1.42	48.75	......	......	......
50	50 pounds of cow manure...	37.5	1.460	30.66	2952	.867	25.59	460	.365	1.68	57.93	7.1	508	9.18
51	100 pounds of cow manure...	33.7	1.536	29.00	3088	.828	25.57	420	.307	1.29	55.86	3.3	604	7.11
52	200 pounds of cow manure...	33.2	1.517	28.23	2668	.879	23.45	432	.326	1.41	53.09	2.8	196	4.34
	Average	33.7	1.498	28.26	2808	.863	24.20	423	.343	1.45	53.91	4.4	436	6.88
	NON-LEGUME SECTION													
53	No manure	22.1	1.133	14.05	2540	.604	15.34	220	.353	0.78	30.17	......	......	......
54	50 pounds of cow manure...	16.1	1.191	10.72	2752	.564	15.52	168	.326	0.55	26.79	......	160	......
55	100 pounds of cow manure...	21.1	1.268	14.96	3036	.671	20.37	208	.334	0.69	36.02	......	484	5.85
56	200 pounds of cow manure...	24.3	1.248	16.97	2580	.604	15.58	220	.315	0.69	33.24	2.2	40	3.07
	Average	20.9	1.210	14.18	2727	.611	16.70	204	.332	0.68	32.05	0.7	228	2.97

The Influence of the Legume

Without exception the yields of grain are larger on the legume than on the non-legume section.

The highest yield on the former is 37.5 bushels per acre, and on the latter 24 bushels per acre. The average yield for the legume section is 33.7 bushels and for the non-legume section 20.9 bushels, thus showing an advantage of 12.8 bushels for the former. The yield of dry stalks is very nearly the same on the two sections.

The percentage of nitrogen is higher in both grain and stalks from the legume than from the non-legume section. It follows, therefore, that the total nitrogen recovered on the legume section is distinctly more than the amount recovered on the non-legume section.

This is shown by an average increase over the check of 6.88 pounds for the legume section and 2.97 pounds for the non-legume section. It is thus shown that of the two green-manure crops, the legume is best from the standpoint of yield and also of the quality of the feeding material produced.

The Influence of the Manure

For the legume section the manured plots show a higher yield of grain and stalks than the check plot. The greatest increase in grain is 398 pounds, or 7.1 bushels per acre, on plot 50. The same plot gives an increase in stalks equivalent to nearly 1/4 ton. The increase, however, is not always proportional to the amount of manure used. Two of the manured plots in the non-legume section show smaller yields than the check plot, and the other manured plot shows only a small increase over the check. Again the legume demonstrates its superiority over the non-legume.

Summary

In the continuous growing of corn with a legume and non-legume green-manure crop and small applications of manure on each, for the introduction of decay organisms, the legume section gave a larger yield of grain with a higher percentage of nitrogen than the non-legume section.

The average yield of dry shelled corn on the legume section was about 13 bushels more than the average yield on the non-legume section.

The average percentage of nitrogen in the grain from the two sections was 1.49 for the legume and 1.21 for the non-legume.

The total nitrogen recovered through the crop from the legume section was 54 pounds per acre and from the non-legume section 32 pounds.

With reference to the manure treatment the treated plots of the legume section gave an average increase over the check plot of 4.4 bushels of grain, whereas the corresponding increase for the non-legume section was only 0.7 bushels.

THE CONTINUOUS GROWING OF WHEAT AND RYE WITH AND WITHOUT A LEGUME AS A GREEN MANURE, 1919

This constitutes the twelfth report of the work that is being carried out on this series of plots. With the exception of a crop of corn in *1908 two plots have been in wheat and two in rye every year since* that time.

The plan provides for seeding one wheat plot and one rye plot to a leguminous green-manure crop immediately after harvesting the grain crop, while two other plots remain in stubble until time to prepare the land for seeding the grain again in the fall.

Thus two of the plots have added to them such nitrogen as the leguminous green-manure crop can accumulate in about 60 days while the other two go without any applied nitrogen. It may be explained here that during recent years there has been a tendency for volunteer clover to come into these two plots that remain in stubble during the summer. This, to some extent, complicates the results, but there seems no way out of the difficulty unless it is to plow the land immediately after harvesting the grain, and this practice could hardly be followed in general farm work, for the reason that just at this season there would not be time for breaking wheat stubble.

All plots receive liberal applications of acid phosphate and muriate of potash and are limed every 5 years. It is this lime and mineral treatment that encourages the growth of clover on the non-legume plots.

Crop of 1919

Immediately after harvesting the grain in 1918 plots 70 and 71 were disked and seeded to Ito San soybeans. A good stand was secured and growth was normal, showing excellent inoculation. Later, much crab-grass came in among the beans. At the time of plowing on September 23 they were 16 to 22 inches high. The ground was further

prepared and acid phosphate applied at the rate of 400 pounds per acre. On account of the scarcity of potash none was applied this year. Ground oyster-shells were applied at the rate of 2 tons per acre.

On October 4 the plots were seeded to wheat and rye in accordance with the plan, namely, plots 68 and 70 to rye and 69 and 71 to wheat. The wheat and rye came through the winter in good condition and continued to grow nicely through the season. In the early part of May, trespassers did slight damage to the wheat on plot 71.

The grain was harvested July 3 and the legume plots again seeded to soybeans. The grain was weighed in the field and samples taken and prepared for analysis. The field weights of grain and straw at harvest time were as follows:

Plot No.		Pounds per acre
Rye	68—No legume	3440
	70—leguminous green-manure	4800
Wheat	69—No legume	2920
	71—leguminous green-manure	4620

The dry weights of grain* and straw, the percentage of nitrogen in the dry matter, and the total nitrogen recovered are shown in table 13.

* The grain of the samples which were saved from plots 68 and 70 was badly damaged by mice so that the weights of these samples could not be used in calculating the yield per acre. The yield per acre for these plots was calculated from the actual field weights of grain and straw, the average proportion of grain to straw for the six years, 1913 to 1918 inclusive, being used as a basis.

TABLE 13

Rye and Wheat with and without Leguminous Green-Manure Crop, 1919
(Calculated to the Acre Basis)

Plot No.		Dry Grain	Nitrogen		Dry Straw	Nitrogen		Total Nitrogen
		lbs.	per cent	lbs.	lbs.	per cent	lbs.	lbs.
Rye	68	1234	1.760	21.72	2560	.576	14.74	36.46
	70	1544	1.740	26.87	3280	.365	11.97	38.84
Wheat	69	800	2.055	16.44	1500	.468	7.02	23.46
	71	1000	1.986	19.86	2660	.519	13.81	33.67

From the figures given in the table it will be noted that the yields on the legume-treated plots are distinctly higher than on the non-legume plots for both wheat and rye.

The former shows an increase of 200 pounds, or over 3 bushels per acre, and the latter an increase of 310 pounds, or over 5 bushels per acre. There is also a substantial increase of straw in both cases.

Mention has already been made of the appearance of volunteer clover in the non-legume plots, especially plot 68. After the rye was harvested from the plot in 1919 notes were made to the effect that there was a fair stand of this volunteer clover—white, alsike and red. Since nitrogen is the limiting factor on this plot, the coming in of the clover tends to bring the yields nearer to the yields on the corresponding legume plot, and to this extent interferes with the carrying out of the experiment in accordance with the original plan. However, the circumstance furnishes good evidence that clover can be grown with little trouble when the conditions are made favorable. There is little difference between the nitrogen content of the dry grain from the legume plot and that from the non-legume plot, but the legume wheat plot yielded about 10 pounds more per acre of total nitrogen than the non-legume plot.

PLATE I

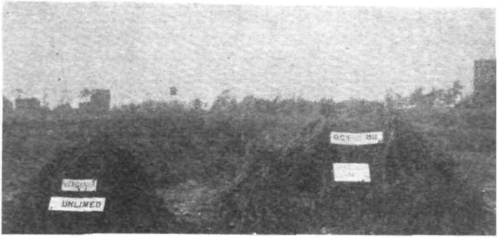

FIG. 1. VIRGINIA SOYBEANS GROWN ON UNLIMED AND LIMED PLOTS, 1918

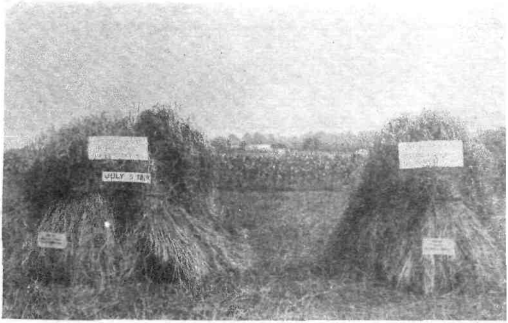

FIG. 2. RYE HARVESTED FROM CONTINUOUS RYE PLOTS, WITH AND WITHOU
A LEGUMINOUS COVER CROP, 1919

REPORT OF THE DEPARTMENT OF PLANT PHYSIOLOGY

Department of Plant Physiology

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* Appointed September 1, 1919.

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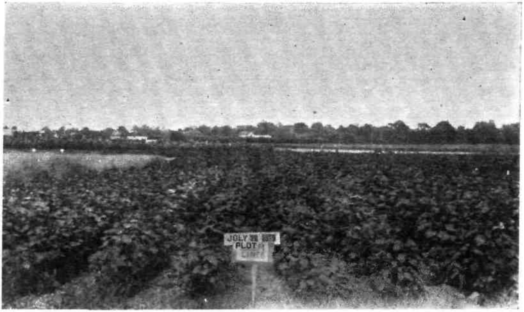

FIG. 1. BAIRD, SWAN AND WILSON SOYBEANS GROWN ON UNLIMED PLOTS, 1919

FIG. 2. BAIRD, SWAN AND WILSON SOYBEANS GROWN ON LIMED PLOTS, 1919

Report of Department of Plant Physiology

John W. Shive

INTRODUCTION

The department of plant physiology has experienced a marked increase in its activities during this year. The principal lines of research which were followed the previous year have been continued with some modifications. With the addition of several new members to the staff of workers new lines of research have been undertaken and the scope of the laboratory activities have been considerably broadened.

Weekly staff meetings were held throughout the year for the discussion of scientific problems and for reviews of current scientific literature along plant physiological lines. These meetings proved highly beneficial in that they added greatly to the interest in the work of the laboratory and kept the members of the staff abreast of the times with respect to the botanical literature constantly appearing.

During the year much needed repairs were made on greenhouse No. 1, in the series of experimental greenhouses. The construction of a concrete superstructure under the framework and the complete remodeling of the interior of this greenhouse, with a certain amount of new equipment, has provided much needed space for experimental work with growing plants and has greatly enhanced the facilities for research in the department. This added greenhouse space together with a certain amount of necessary apparatus which has been acquired during the year has made the condition for investigational work in the laboratory of plant physiology along certain lines better than they have ever been before.

While the equipment of the laboratory and of the experimental greenhouses is by no means complete the greatest need of the department at the present time is more laboratory and office space which could be made available by the completion of the second story of the laboratory building provided for in the original plan of the building.

Personnel

During the year several additions and changes were made in the personnel of the department. Linus H. Jones of the Massachusetts Agricultural College, who was appointed to the Ammonium Sulphate Fellowship established by the Barrett Company of New York, assumed the duties of this fellowship August 1. E. L. Sargent, of the Colorado Agricultural College, was appointed research assistant and took up the duties of this position August 1. Mr. Sargent has since received an appointment to the position of instructor in chemistry in Rutgers College and has therefore tendered his resignation as research assistant in this department to assume the duties of his new position at the beginning of the fiscal year, July 1. Mr. Van Alstine who has been doing his major work for the degree of Doctor of Philosophy in plant physiology has completed his work and the degree was conferred upon him in June. Miss Fiske also has completed her major work in plant physiology for the degree of Master of Science. This degree was conferred upon her in June. Mr. Haenseler, Mr. Poole and Mr. Joffe, who are pursuing work in the State University of New Jersey leading to the degree of Doctor of Philosophy, are making plant physiology the subordinate subject, and as graduate students are carrying on research in the laboratory of plant physiology.

Investigation and Related Activities

Increase in the number of workers, somewhat better facilities, larger working space, and various other conditions have rendered the amount of research accomplished during the year greater than in any previous year. The results of the work dealing with the relation of moisture content in sand cultures to physiological balance of nutrient mixtures in solutions diffused as films over the sand particles, were published during the year and the work was continued with soil cultures. The results of the work with soil cultures are now being prepared for publication.

The experimentation dealing with the influence of sand of different degrees of fineness upon the reaction and upon the effective concentration of nutrient solutions for plants was completed during the year and the results have been published.

Studies on the salt nutrition of agricultural plants, cooperative research under the auspices of the National Research Council, Special Committee on Salt Requirements of Representative Agricultural *Plants, has been continued with wheat in solution and sand cultures and with potatoes; some progress has been made.*

Mr. Van Alstine was engaged in the study of the relation of the hydrogen-ion concentration to plant growth, and of the influence of

plant growth upon the reaction of the media in which the plants were grown. A portion of this work has been completed and is now ready for publication. Mr. Van Alstine has devoted considerable time and energy also to the development of methods and apparatus for the convenient and accurate determination of the hydrogen-ion concentrations of nutrient solutions for plants, water extracts of soils, etc., by the use of indicators.

The study of ammonium sulfate in relation to plant growth, first, as a constituent in a complete fertilizer ration for plants, and second, as an agent for releasing unavailable mineral nutrients for plants in the soil, has been undertaken by Mr. Jones. The work is being conducted with water cultures and soil cultures in the greenhouse. Field tests also are being made.

During the year research was undertaken in this laboratory in an endeavor to obtain some definite information with respect to the use of iron as one of the essential constituents of nutrient media for culture studies with green plants. Investigation of the conditions under which plants can best obtain the iron necessary for growth, and the condition or form of the iron which is best adapted for absorption by the roots of different species of plants under given sets of experimental conditions, has been woefully neglected. The employment of the usual "trace" of iron in culture media without regard to its constitution or to the nature of the media to which it is applied, has proved entirely inadequate for some species of plants and has sometimes led to doubtful if not clearly erroneous conclusions in the interpretation of plant responses toward the media in which they were grown. During the year Mr. Sargent has been engaged in the study of certain phases of the iron problem, and some progress has been made.

Mr. Neller on his return to the station from military service overseas, again took up his studies on the influence of growing plants upon the activity of soil microorganisms, using as an index the evolution of carbon dioxide from the soil. Mr. Neller has completed this work, the results of which are now being prepared for publication.

THE INFLUENCE OF VARYING DEGREES OF SOIL MOISTURE UPON THE PHYSIOLOGICAL SALT BALANCE FOR PLANTS

John W. Shive

The following report presents in a preliminary way some of the main results of an experimental study dealing with the influence of different degrees of moisture in soil cultures upon the balance of salt proportions as these affect the growth of plants. This study corresponds to a similar investigation carried out with wheat in sand cultures.

The present work was carried out with buckwheat in soil cultures. The soil used consisted of a rich sandy loam which was mixed in the air-dry condition in equal proportions by volume with white seashore sand which had previously been thoroughly washed and air-dried. The fertilizer salts were added to the soil cultures in the form of mixed solutions, each containing the three salts, KH_2PO_4, $Ca(NO_3)_2$ and $MgSO_4$. These solutions comprised a series of 21 different sets of salt proportions of the three salts, produced by making the volume-molecular partial concentrations of each salt differ from solution to solution by increments of one-eighth of the total volume-molecular concentration.

The solutions were added to the air-dry soil in such quantities as to produce the same initial moisture conditions in all the cultures of a single series. Three series of cultures were employed, which were alike with respect to the salt proportions but differed from each other in the degree of the moisture content of the cultures. All the cultures of one series were prepared to have a moisture content of 30 per cent of the moisture-retaining capacity of the soil, the cultures of another series had a moisture content of 60 per cent, and those of a third series a moisture content of 80 per cent of the maximum water-holding capacity of the soil. The second of these values gave a moisture content which was well within the range for optimum growth, while the first and third values gave moisture contents which were, respectively, below and above this range.

The constant initial differences in the moisture content of the cultures of the three series make inevitable certain other environmental differences in corresponding cultures of the different series, according to the total salt concentration and the amounts of the solutions added to the cultures to give the required differences in moisture content. The environmental differences in question naturally give rise to three sets of experimental possibilities, each set involving the three series of cultures above described. The three possibilities may briefly be stated as follows: (1) When the required differences in moisture content are produced by adding equal quantities of solutions all having the same total salt concentrations, to corresponding cultures of the three series throughout, the total salts per culture thus being approximately equal, the amounts of soil used per culture are inversely proportional, and the total salts per unit volume of soil are directly proportional to the required moisture contents. (2) When the required differences in moisture content are produced by adding unequal amounts of solutions, all having the same total salt concentrations, to corresponding cultures of the three series, the quantities of soil used per culture being equal, the total salts per culture and the total salts per unit volume of soil are directly proportional to the required moisture contents. (3) When the required differences in moisture content are produced by adding to corresponding cultures of the three series

different amounts of solutions, with the quantities of soil used per culture, the total salts per culture, and the total salts per unit volume of soil equal throughout, the total salt concentrations of the solutions are inversely proportional to the required moisture contents.

These experimental possibilities representing the unavoidable sets of environmental differences with the given differences in moisture content of the corresponding cultures of the three series are set forth in numerical form in table 1. The table is divided into three horizontal sections, each section giving the data of a single group of cultures comprising three series, and representing one of the three sets of experimental possibilities. The weights of the air-dry soil used per culture, the amounts of solutions added to the soil to give the required moisture contents, and the approximate total concentrations of the solutions are given. The volume-molecular proportions of the 21 different solutions in each series of the three g

TABLE 1

Numerical data describing the initial treatment and condition of the soil cultures employed in groups I, II and III

	Series	Amount of soil used per culture	Soil moisture content based on water retaining capacity of soil	Total amount of solution added to soil of each culture	Approximate concentration value of solutions added to cultures	Total salts per culture relative to those in cultures of series B taken as unity	Total salts per unit volume of soil relative to those in cultures of series B taken as unity
		gm.	per cent	cc.	atm.		
Group I	A	3200	30	299	1.75	1.00	0.50
	B	1600	60	299	1.75	1.00	1.00
	C	1200	80	299	1.75	1.00	1.33
Group II	A	1600	30	149	1.75	0.50	0.50
	B	1600	60	299	1.75	1.00	1.00
	C	1600	80	399	1.75	1.33	1.33
Group III	A	1600	30	149	3.50	1.00	1.00
	B	1600	60	299	1.75	1.00	1.00
	C	1600	80	399	1.31	1.00	1.00

table 2. The solution numbers refer to the positions which the solutions occupy in the series with respect to the triangular diagram

TABLE 2

Volume-molecular proportions of KH_2PO_4, $Ca(NO_3)_2$ and $MgSO_4$ in solutions applied to soil cultures in proper amounts to produce a soil moisture content of 30 per cent, 60 per cent and 80 per cent of the water-retaining capacity of the soil in series A, B, and C, respectively.

Solution Number	VOLUME-MOLECULAR PROPORTIONS								
	Series A, B, and C of groups I and II, and series B of group III (approximate osmotic concentration value, 1.75 atmospheres)			Series A of group III (approximate osmotic concentration value, 3.50 atmospheres)			Series C of group I] (approximate osmot concentration valu 1.31 atmospheres)		
	KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$	KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$	KH_2PO_4	$Ca(NO_3)_2$	MgSC
R^1S^1 ...	.0047	.0047	.0282	.0094	.0094	.0564	.0035	.0035	.021
S^2 ...	.0044	.0086	.0215	.0088	.0172	.0430	.0033	.0064	.016
S^3 ...	.0042	.0124	.0164	.0084	.0248	.0328	.0031	.0093	.012
S^4 ...	.0039	.0156	.0117	.0078	.0312	.0234	.0029	.0117	.008
S^5 ...	.0039	.0189	.0075	.0078	.0378	.0150	.0029	.0142	.005
S^6 ...	.0035	.0213	.0035	.0070	.0426	.0070	.0026	.0160	.002
R^2S^1 ...	.0093	.0047	.0281	.0186	.0094	.0562	.0069	.0035	.017
S^2 ...	.0086	.0086	.0173	.0172	.0172	.0346	.0064	.0064	.013
S^3 ...	.0082	.0124	.0124	.0164	.0248	.0248	.0062	.0093	.009
S^4 ...	.0079	.0158	.0079	.0158	.0316	.0158	.0059	.0118	.005
S^5 ...	.0072	.0182	.0037	.0144	.0364	.0074	.0054	.0136	.002
R^3S^1 ...	.0135	.0044	.0177	.0266	.0088	.0354	.0100	.0033	.013
S^2 ...	.0126	.0084	.0126	.0252	.0168	.0252	.0094	.0063	.009
S^3 ...	.0119	.0119	.0079	.0238	.0238	.0158	.0089	.0089	.005
S^4 ...	.0114	.0151	.0037	.0228	.0302	.0074	.0085	.0113	.002
R^4S^1 ...	.0175	.0044	.0130	.0346	.0088	.0260	.0130	.0033	.009
S^2 ...	.0165	.0082	.0082	.0330	.0164	.0164	.0123	.0062	.006
S^3 ...	.0158	.0119	.0039	.0316	.0238	.0078	.0118	.0089	.002
R^5S^1 ...	.0215	.0042	.0086	.0430	.0084	.0172	.0161	.0031	.006
S^2 ...	.0206	.0082	.0040	.0412	.0164	.0080	.0155	.0062	.003
R^6S^1 ...	.0254	.0042	.0042	.0508	.0084	.0084	.0190	.0031	.003

graphically representing the variations in salt proportions and partial molecular concentrations of the three-salt solutions here employed in soil cultures.[1]

To make the study as complete as possible the three groups of cultures as outlined in table 1, each group comprising three series, were conducted simultaneously. Each series included, in addition to the 21 treated cultures, two check cultures which were prepared by adding

[1] For a description of this diagrammatic scheme see, "A plan for cooperative research on the salt requirements of representative agricultural plants" prepared for a Special Committee of the Division of Biology and Agriculture of the National Research Council. Edited by Burton E. Livingston; Baltimore, 1919.

distilled water instead of solution to the air-dry soil to produce the required moisture content. For convenience the groups are numbered consecutively I, II, and III, and the series of each group are designated series A, B and C, according as the moisture content employed in the series was 30 per cent, 60 per cent or 80 per cent, respectively.

TABLE 3

Average dry weights of the highest seven yields of buckwheat tops from each of the three series grown to the flowering stage in the soil cultures of group I

Culture number	Average Dry Weights (4 Plants per Culture)					
	Series A, 30 per cent moisture		Series B, 60 per cent moisture		Series C, 80 per cent moisture	
	Absolute	Relative to check as unity	Absolute	Relative to check as unity	Absolute	Relative to check as unity
	gm.		gm.		gm.	
Check	0.8498	1.00	1.1010	1.00	0.4829	1.00
R^1C^2	1.9976	2.35	....	....	....	....
R^1C^6	2.2424	2.64	....	....	2.4892	5.16
R^1C^4	2.2520	*2.65*	3.1509	*2.87*	2.5760	*5.32*
R^1C^5	....	....	3.2918	2.99	....	....
R^2C^3	....	....	3.3113	3.01	2.4689	5.12
R^2C^4	2.3186	*2.73*	3.1674	*2.88*	2.5505	*5.28*
R^2C^5	2.2625	*2.66*	3.3878	*3.08*	2.5342	*5.24*
R^3C^2	....	....	....	....	2.5581	5.30
R^3C^3	....	....	3.0160	2.74	....	....
R^3C^4	2.2863	*2.68*	3.3692	*3.06*	2.7488	*5.70*
R^4C^2	2.2431	2.64	....	....	....	....

Half-gallon glazed earthenware pots were used as culture vessels for all cultures except those of series A in group I, which required larger pots, and those of series C of the same group, for which somewhat smaller pots were used. Selected buckwheat seedlings when about 3 to 4 cm. tall were transplanted to the prepared soil cultures from a germinating net, four seedlings to each culture. The cultures were continued to the flowering stage of the plants, requiring a period of 28 days from the time of transplanting. The cultures were then repeated, so that two corresponding sets of measurements were available for each culture, and by combining these the average measurements were obtained.

To prevent evaporation from the surface of the soil, all the cultures were sealed at the beginning of the experiment. Excessive changes in the moisture content of the cultures through transpiration were prevented by weighing the cultures daily during the early stages of growth, sufficient amounts of distilled water being added to the cultures at each weighing to restore the original moisture content. During the later growth stages the cultures were weighed twice daily and the original moisture content of the cultures restored.

TABLE 4

Average dry weights of the highest seven yields of buckwheat tops from each of the three series grown to the flowering stage in the soil cultures of group II

Culture number	Average Dry Weights (4 Plants per Culture)					
	Series A, 30 per cent moisture		Series B, 60 per cent moisture		Series C, 80 per cent moisture	
	Absolute	Relative to check as unity	Absolute	Relative to check as unity	Absolute	Relative to check as unity
	gm.		gm.		gm.	
Check	0.8455	1.00	1.1010	1.00	0.5953	1.00
R^1C^4	1.7928	2.12	3.1569	2.87	2.4070	4.05
R^1C^5	2.0667	2.45	3.2918	2.99	....	....
R^1C^9	1.9132	2.26	....	....	2.4261	4.08
R^2C^3	1.8601	2.20	3.3113	3.01	2.4720	4.15
R^2C^4	1.9859	2.35	3.1673	2.88	3.0407	5.11
R^2C^5	1.8811	2.23	3.3878	3.08	2.4330	4.08
R^3C^3	....	....	3.0160	2.74	2.6455	4.44
R^3C^4	1.9858	2.35	3.3692	3.06	2.6919	4.52

On account of the great difficulty of obtaining accurate measurements of roots that have been grown in soil, measurements of tops only will be given. Since medium and low yields are of little interest in this connection, only the highest seven (upper one-third) yields from all the cultures in each series will be considered. The average absolute and relative yield values from these best seven cultures in each of the three series in group I are given in table 3, while tables 4 and 5 present corresponding data obtained from the series of groups II and III. The culture numbers correspond to the solution numbers as given in table 2, designating the solutions which were employed with the cultures in question, to produce the required initial moisture content. These culture numbers refer to the positions which the

cultures occupy in the series with respect to the triangular diagrams to which reference has already been made.

Referring to the columns of dry weights of tops in table 3, it will be observed that of the seven cultures in each series which produced high yields, four are corresponding cultures of the three series. The average relative yield values of the four cultures in question are indicated in italics in the table. These four cultures, R^1C^4, R^2C^4, R^2C^5, and R^3C^4 are characterized, with respect to the salts added to the soil,

TABLE 5

Average dry weights of the highest seven yields of buckwheat tops from each of the three series grown to the flowering stage in the soil cultures of group III

Culture number	Average Dry Weights (4 Plants per Culture)					
	Series A, 30 per cent moisture		Series B, 60 per cent moisture		Series C, 80 per cent moisture	
	Absolute	Relative to check as unity	Absolute	Relative to check as unity	Absolute	Relative to check as unity
	gm.		gm.		gm.	
Check	0.7007	1.00	0.7926	1.00	0.4576	1.00
R^1C^2	1.2737	1.79			1.1887	2.60
R^1C^4			1.6945	2.29		
R^1C^5			1.7920	2.41	1.1167	2.45
R^1C^6					1.1612	2.54
R^2C^2	1.2707	1.79			1.1113	2.43
R^2C^3			1.6608	2.24		
R^2C^4			1.6636	2.24		
R^2C^5	1.2633	1.77	1.6962	2.29		
R^3C^3	1.3782	*1.94*	2.0045	*2.70*	1.2420	*2.71*
R^3C^4	1.3060	1.84	1.7174	2.32		
R^4C^2					1.3420	2.93
R^5C^2	1.5016	2.11			1.2725	2.78
R^6C^1	1.4634	2.05				

hy relatively low proportions of KH_2PO_4, high proportions of $Ca(NO_3)_2$, and relatively low proportions of $MgSO_4$. These four cultures include those which produced the maximum yields in the three series, although the maximum yields were not produced by corresponding cultures. It is to he noted, however, that the range in the values of the seven high yields in any one series is not great, and that the differences in the salt proportions producing the maximum

The fact that the high-yielding cultures in each of the three series of this group all occupy similar positions in the series with respect to the salt proportions of the solutions added to the cultures to produce the *initial* soil moisture, indicates that under this set of experimental conditions (see table 1, group I) the differences in the degrees of soil moisture in the three series had no marked influence upon the physiological balance of the fertilizer constituents which produced high yields.

The series of group II (table 4) are in very close agreement with those of group I (table 3) with respect to the cultures which produced high yields. Inspection of table 4 brings out the fact that of the seven high yields from each of the three series of group II, five were produced by corresponding cultures of the three series, and four of these five cultures, R^1C^4, R^2C^4, R^2C^5, and R^3C^4, correspond to the four cultures which produced high yields in each of the three series of group I. It is thus evident that with the experimental conditions under which the cultures comprised in the series of group I and group II (see table 1) were carried out, the results with respect to the rates of growth and yields produced are practically the same under the two sets of conditions, and no clear evidence is found that differences in the moisture content of the substratum here used have any pronounced influence upon the salt balance as this affects the growth of buckwheat.

A comparison of the data in table 5 with those in tables 3 and 4, brings out the fact that the results obtained with the three series of group III are strikingly different from those obtained with the series of the other two groups. The data in table 5 show that from the high-yielding cultures of the three series of this group only one culture, R^3C^3, is common to both series. The cultures corresponding to this one in the series of the other two groups did not all produce high yields, so that there is no point of agreement between this group and the other two groups, as a whole, with reference to the balance of the fertilizer rations producing high yields. It is thus clear that the physiological balance of the salt proportions which produced the high yields in the series of this group is not at all the same as that which produced corresponding yields in the series of the other two groups. The explanation of this appears in the fact that the total concentration values of the solutions employed to produce the required initial soil moisture are different in the three series of this group and they are not the same as those of the solutions employed with the series of the other two groups, except the B series, which are the same in each group (see table 1). The total concentration values of the solutions employed with the three series of group III were approximately 3.50 atmospheres for series A, 1.75 atmospheres for series B, and 1.31 atmospheres for series C, while the solutions employed with the cultures comprised in the series of the other two groups all had approximately the same total osmotic concentration value, 1.75 atmospheres. Thus with approximately constant total concentrations of the solu-

tions added to the soil cultures to produce the initial differences in the degrees of soil moisture employed with the different series of groups I and II, the fertilizer proportions which indicated good physiological balance for growth with the lowest soil moisture showed good balance also with the medium and highest soil moisture. With a change in the total concentration of the solutions employed, the good balance of the fertilizer proportions was greatly altered.

Inspection of the columns of absolute dry-weight values in tables 3, 4 and 5, shows that seven high yields from series B in each of the three groups are always much higher than are the corresponding yields in either series A or series C, in which the lowest and highest soil moisture, respectively, was employed in each of the three groups. In group I, the average of the seven high yields from series B, as given in table 3, is 46 per cent higher than the corresponding average in series A and 27 per cent higher than that in series C. In group II this average for series B is 68 per cent and 33 per cent higher, and in group III it is 30 per cent and 46 per cent higher than that in series A and series C, respectively. This clearly shows that a complete fertilizer with the salt constituents well balanced for plant growth requires approximately optimum moisture conditions of the soil to which it is applied in order to impart to it its maximum physiological value or plant-producing power. With a good salt balance for plant growth and approximately optimum soil-moisture conditions, a medium fertilizer application has greater plant-producing power than a heavier application, with the moisture content of the soil to which it is applied either above or below the optimum for plant growth. It is to be noted also that the differences in the growth rates brought about by differences in the moisture content of the soil, as indicated by the differences in the yield values of corresponding cultures of the three series in each group, are just as pronounced as are the differences in the rates of growth resulting from the variations in the proportions of the fertilizer constituents throughout each series. It thus appears that the actual physiological value or plant-producing power of any given set of fertilizer constituents is dependent to a very large extent upon the moisture conditions of the soil to which the fertilizer is applied.

THE INTERRELATION BETWEEN PLANT GROWTH AND THE ACIDITY OF NUTRIENT SOLUTIONS

ERNEST VAN ALSTINE

This study naturally divides itself into two main parts: the effect of the growing plant upon the reaction of the nutrient solution, and the effect of the reaction of the nutrient solution upon the growth of plants. Both of these bear important relations to the mechanism by

which mineral nutrients are taken up by the plant from the soil solution. Because the methods of experimental procedure in studying the two divisions of the subject differ somewhat, the experimental results may well he considered separately.

Effect of Plant Roots Upon the Reaction of Nutrient Solutions

Certain salts which may be used in nutrient solutions may be either physiologically alkaline or physiologically acid. Thus, by selective absorption from sodium nitrate, plants will take up relatively more of the nitrate radical than of the sodium, leaving the sodium to make the culture medium less acid or more alkaline. Similarly, ammonium sulfate may be a physiologically acid salt. It is not the effects produced by such selective ion absorption that are considered in this discussion of the effect of plant roots upon the reaction of solutions, but simply the effect which plant roots seem to have aside from such absorption.

That carbon dioxide is given off by the roots of plants has been known for a long time. Becquerel (2) was the first to suggest that some acid other than carbon dioxide is given off by plant roots. Mazé, Rout and Lemoigne (5, 6) believe that malic acid is secreted by maize roots, and Czapek (3) gives a list of a number of acids reported by several investigators as having been found in the excretions of plant roots. Czapek himself believes that acid salts are excreted by roots and that the most important acid salt is the primary potassium phosphate.

The excretiou of organic acids, of acid salts or of carbon dioxide should have a tendency to make the medium more acid, unless the effect is in some way neutralized or counteracted. It is the belief of those who advocate the theories that these substances are excreted, that the acid reaction is neutralized by soil minerals which are, by the process, made soluble and available to the plants. When plants are growing in distilled water in which there is nothing present to neutralize root excretions, the reaction of the water should gradually increase in acidity as the concentration of root excretion increases. In this study plants were grown in distilled water for varying lengths of time and the reaction of the water then determined. Because of the possible influence npon the reaction of excretion of salts absorbed from solutions in which the plants were growing previous to the placing of them into the distilled water, more than one sort of nutrient solution was used in which to grow the plants before placing them into the water. Some of the plants were repeatedly changed from nutrient solution to distilled water, hack again to nutrient solution, and again placed into distilled water. The changes in reaction of the nutrient solution and of the water were observed. Aberson (1) and Haas (4) in similar studies removed the carbon dioxide from the solution before making their determinations, but in this work observations were

made without removing carbon dioxide. Table 1 gives the reaction, expressed as pH values, towards which the plants studied tended to change the distilled water. The greatest variations in either direction from this average point as found in any of the several determinations also are shown.

TABLE I

Hydrogen-Ion Concentration values toward which plants apparently tend to change the reaction of distilled water

Names of Plants.	pH values to which plants finally changed distilled water (average)	Greatest variation from average pH value
White navy beans	4.6	—0.0 +0.2
Soybeans	4.9	—0.9 +0.2
Canada field peas	4.9	—0.2 +0.3
White lupine	5.1	—0.4 +0.1
Corn	4.6	—0.6 +0.3
Wheat	4.7	....
Buckwheat	4.2	....
Rape	4.8	—0.2 +0.2
Radish	6.4	....
Watermelon	4.9	—0.7 +0.4
Cantaloupe	6.1	—0.2 +0.2
Lettuce	5.1	—0.2 +0.2
Field sorrel	4.6	—0.2 +0.2

While the reaction of the distilled water was always brought near to the average figure given in table 1, regardless of the solution in which the plants had been growing previously, the acidity of the nutrient solution was increased by some species and decreased by others. This effect upon the nutrient solution may have been due partly or wholly to selective ion absorption.

The amount of acidity developed when selective ion absorption does not play a part is not very great, even with plants such as sorrel, which

contains considerable amounts of oxalic acid and grows well on acid soils. It would take but a very small amount of soil material to change the reaction of the solution from that produced by the plant to the neutral point, a pH value of 7.0. If neutralization of the acid reaction brought about by the plant were the only way soil nutrients could be made available to plants, it seems that the nutrients would not be made available rapidly enough to supply the plant's needs. This in particular would be true in soils containing a large amount of calcium carbonate, which would neutralize a large part of the acidity resulting from plant growth. If, by dissolving small amounts of soil nutrients, the slight acidity serves merely to put these nutrients into a form such that interchange of basic or acidic parts of the salts may take place between soil solution and plant tissues, then such slight acidity as that represented by pH values of from 4.2 to 6.4 may play a very important role in plant nutrition.

Effect of Solution Reaction Upon Plant Growth

This part of the work was carried out for the purpose of determining about what degree of acidity certain agricultural plants can withstand without being injured. In addition to this question, interesting information was obtained regarding the availability of iron in the form of the ferric phosphate when used in solutions of differing degrees of acidity. Injury due to acidity and availability of iron as observed in these experiments bear such a relation to each other that it seems well to discuss both at the same time.

The culture solutions used in this work were Shive's (7) three-salt solutions, either unchanged or modified to have reactions corresponding to the pH values desired. To change the reaction of the original solution, either the acids or the hydroxides corresponding to the salts used in the solution were added to the solution in amounts sufficient to produce the desired reaction. This was done in such a way as to keep the proportions of the cations (atoms or atomic groups) always the same throughout the series, and likewise the proportions of the anions (acid radicals) were always kept the same.

In the first series, soybeans were grown in Shive's solution R^5C^2 modified to give the following pH values: 3.2, 3.4, 3.6, 3.8, 4.0, 4.6, 5.8, 6.0 and 6.4.

Within 10 days from the time the cultures were started all of those plants started in solutions having pH values of 3.2, 3.4 and 3.6 had died, apparently from the effects of too strong acid in the culture solution. All of the plants, especially the roots, in the solution having a pH value of 3.8 were injured during the first ten days of the experiment, but two of them recovered in a short time and no sign of injury that could be attributed to the acidity of the nutrient solution was evident.

The results obtained appear to show that soybean plants are not injured by the acidity of the nutrient solution corresponding to a pH value of 4.0, but cannot withstand an acidity greater than this without injury, especially to the roots. This is shown by the fact that during the first few days of growth, in a solution with a pH value of 3.8, the roots of the plants were severely injured.

Iron in the form of a ferric phosphate was used in all the solutions at the rate of 0.0022 gm. per liter of solution. Shortly after the cultures were started, the plants in those solutions having pH values of 5.8, 6.0 and 6.4 began to show chlorosis and at the time of harvesting, 29 days after the cultures were started, nearly all the plants in these solutions had died without having produced much growth. Comparison with results obtained where a soluble form of iron in equivalent amounts per liter of solution was used, indicates that chlorosis was due to the inability of the plants to obtain a sufficient amount of iron from the solutions with low acidity. Judging from the chlorotic condition of the plants in the solutions with low acidity and the absence of this condition of the plants in the solutions with high acidity, it appears that the availability of iron in the phosphate form varies in the same order as does the degree of acidity of the solutions. There was little evidence of chlorosis in any of the plants growing in solutions having pH values of 3.8, 4.0 or 4.6. The acidity of these culture solntions appears to be sufficient to dissolve and make available the necessary amount of iron for the normal development of the plants from the form and amounts here used.

The second series consisted of buckwheat plants grown in Shive's three-salt solution number R^4C^2, modified to have initial hydrogen-ion concentrations, corresponding to pH values of 3.3, 3.5, 3.7, 4.0, 4.1, 4.7, 5.0, 5.3, 5.5, 5.7, 5.8, 6.0 and 6.2. The same form of iron and the same amounts per liter of solution were used in this experiment as in the preceding one. The plants were grown 21 days from the time of transplanting to the time of harvesting.

No plants died from acid injury, but there was injury, apparently from the acidity of the solution, to plants growing in the solutions having pH values of 3.3, 3.5, 3.7 and 4.0. The injury to plants growing in the solution having a pH value of 4.0 was very slight, however. There was no apparent injury to the plants of any of the other cultures. It thus appears that buckwheat can withstand, for at least 21 days, an acidity corresponding to a pH value of 3.3, but that an acidity below that corresponding to a pH value of 4.0 must be reached before all injurious effects of acidity are eliminated.

There was slight chlorosis in the leaves of one plant growing in the solution having a pH value of 4.7 and in the leaves of one plant growing in the solution having a pH value of 5.0. All plants in solutions having a lower acidity than that corresponding to a pH value of 5.0 showed more or less severe chlorosis.

The third series of cultures was practically the same as the preceding series, except that the plants were grown to maturity. The solutions had initial hydrogen-ion concentrations corresponding to the pH values 3.3, 3.5, 3.7, 3.8, 4.1, 4.7, 5.0, 5.3, 5.5, 5.7, 5.8, 6.0 and 6.4.

Marked injury which could be attributed to the acidity of the solutions appeared only in those cultures having pH values of 3.3 and 3.5, and even these two cultures produced seed. Chlorosis was slightly evident in plants growing in the solution having a pH value of 4.1. It was quite severe in plants growing in solutions having pH values of 5.0 and 5.3, and was so severe in the plants growing in solutions of still less acidity that no seed was produced at all.

Under the conditions of growth in this series, the range of acidity through which the plants were able to withstand the acidity satisfactorily and get sufficient amounts of iron to supply their needs, was from about 3.7 to 4.1.

In series similar to the preceding ones bnt in which the iron, in amounts per liter of solution equivalent to the ferric phosphate here used, was supplied in the form of ferrous sulfate, no chlorotic effect became evident in the plants at any stage during the growth period, although the pH values of some of the solutions were as high as 6.5 and 6.7. It is thus clearly evident that the semi-colloidal ferric phosphate in quantities such as were here used is not sufficiently availahle to enable the plants to obtain the iron necessary for normal growth unless the hydrogen-ion concentration of the solutions are high enough to correspond to pH values of about 4.0 or less. The degree of acidity of the medium in which plants grow may play a very important part in the availability of insoluble plant nutrients.

The two species of plants here used as indicators (soybeans and Japanese buckwheat) appear to possess immunity from acid injury to practically the same degree. Each was able to withstand without apparent injury a hydrogen-ion concentration of the nutrient solution used corresponding to a pH value of about 4.0. However, the degree of acidity of this solution which will actually kill the plants or prevent growth is mnch greater for buckwheat than it is for soybeans.

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THE INFLUENCE OF GREEN PLANTS UPON THE OXIDIZING FLORA OF THE SOIL

J. R. NELLER

During the latter part of 1916 experiments were started, the object of which was to obtain some definite information concerning the influence of growing plants upon soil biological processes. After a lapse of over two years the experiments were resumed in much the same manner as before except that through the advice and cooperation of Dr. J. W. Shive a larger and better apparatus than the one formerly used was assembled.

It is believed that of all the various indices of retarding or stimulating influences of the biological activities of the soil a measure of the production of carbon dioxide is the most accurate. In order to study the effect of growing plants upon carbon-dioxide production the plants and soil were enclosed in systems through which air freed from carbon dioxide was drawn by gentle suction. Each of these systems, of which there were twelve, consisted of a glazed earthenware jar 16 cm. in diameter and 15 cm. high, to the top of which was sealed a wooden base by means of shellac. The center of the base was removed to correspond to the inside diameter of the jar and the upper surface was grooved to receive an inverted battery jar 22 cm. in diameter and 30 cm. high. Each jar was connected with a barium hydroxide absorption tower in which the carbon dioxide evolved in the enclosed system was retained and measured volumetrically. A slow but continuous flow of air through the enclosed system was maintained by means of an aspirating pump to which water was supplied from a constant-level tank. Because of the fluctuating greenhouse temperature many difficulties were encountered in the attempt to keep the apparatus air-tight.

It was found expedient to plant seeds in soil contained in paraffined drinking cups and to transfer the soil and seedlings without disturbing the roots to the soil contained in the glazed jars of the apparatus. These jars held 2,000 gm. of soil. Since the plants grown in the apparatus were necessarily in an atmosphere almost continuously

Since the carbon dioxide of the indrawn air was removed, the only source of carbon dioxide within the apparatus was the decomposition of the organic matter in the soil. Thus the carbon dioxide required for the needs of the plants was first evolved from the soil in which their roots were growing. The carbon dioxide which was not used by

TABLE 1

Total production of carbon dioxide in unplanted jars and in jars planted with soybeans

	Titration intervals	Planted Jars			Unplanted Jars		
		Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
	days	gm.	gm.	gm.	gm.	gm.	gm.
CO_2 evolved from soil and determined by titration	0 –6	206.2	136.2	235.2	399.4	294.9	340.2
	7 –10	149.0	106.8	207.0	225.1	199.8	209.8
	11 –14	137.5	77.0	165.3	210.0	93.7	156.9
	15 –17	144.9	123.2	199.2	222.8	222.8	122.8
	18–24	280.5	175.1	232.2	455.8	263.4	328.2
Total		918.1	618.3	1038.9	1513.1	1174.6	1157.9
Dry weight of crop.........		1402.0	1764.8	1547.8	....	....	....
Weight of ash.............		277.8	625.5	320.3	....	....	....
Organic matter in crop.....		1124.2	1139.3	1227.5	....	....	....
Organic matter in seedlings (estimated)		425.0	425.0	425.0	....	....	....
Organic matter produced during experimental period...		699.2	714.3	802.5	....	....	....
CO_2 fixed by plants during experimental period		1201.9	1227.9	1379.5	....	....	....
Total CO_2 evolved from soil		2120.0	1846.2	2418.4	1513.1	1174.6	1157.9
Average		....	....	2128.2	....	....	1281.8
Ratio of planted to unplanted		....	....	1.66	....	....	1.00

the plants was retained in the absorption towers. All of the carbon dioxide evolved in the control apparatus in which no plants were growing was retained in the absorption towers. The total carbon dioxide from any one enclosed system is of c

In the work (1) reported in 1917 barley and buckwheat plants were grown in pure sand moistened with a nutrient solution, inoculated with a soil infusion, and supplied with a small amount of organic matter. In every case the culture media in which the plants were grown produced slightly more carbon dioxide than did the checks of unplanted jars and all the evidence pointed to the conclusion that the growing roots did not inhibit the decay of organic matter. In the enlarged and improved apparatus used during 1919 and 1920 the cultures were conducted in triplicate and more definite results were obtained.

Table 1 sets forth the summarized results of one of the six experiments which have been carried out. Each of the six jars used in this experiment contained 2,000 gm. of a sieved and partially air-dried loam soil of which the total carbon content was 1.218 per cent. The soil was very slightly acid, as was indicated by the hydrogen-ion exponent of a water extract of the soil which had a value of 6.7.

Five soybean seedlings were planted in each of the three jars while the remaining three were without plants. The experiment was continued 24 days and the plants were then harvested. Table 1 gives the total dry weights of the yields from which the ash and estimated seedling weights were subtracted and the total carbon approximately determined, and the amount of carbon dioxide used by the plants calculated.

It will be observed from table 1 that considerably more carbon dioxide was retained in the barium-hydroxide-absorbing towers connected with the unplanted jars, but when the carbon dioxide used by the plants is included in the total amount evolved from the soil it is clear that the recovery of carbon dioxide from the planted soil was much greater than the total amount obtained from the unplanted soil, the ratio of the former to the latter being 1.66 to 1.00.

In similar tests with Canada field peas, wheat and buckwheat, the increase of carbon dioxide from the planted soil over that from the unplanted soil was 70.8 per cent, 103.8 per cent, and 116.5 per cent, respectively. Tests with buckwheat and soybeans grown in pure sand, inoculated with a soil infusion, and supplied with organic matter, gave only a slight increase of carbon dioxide over that evolved from the unplanted sand.

Since the only source of carbon dioxide was the organic matter of the soil placed within the apparatus, it follows that a greater carbon-dioxide recovery from the planted soil indicates that the growing plants stimulated the oxidation processes in the soil. All of the plants which were tested caused an increased carbon-dioxide evolution from the soil. This appears to indicate a symbiotic relationship between the plants and the microorganisms which are concerned with the oxidation of the organic matter in the soil.

ers of

material may be oxidized during the subsequent growth of the plants and the carbon dioxide thus liberated becomes a part of the amount recovered from the soil. Thus during the period of growth a carbon-dioxide cycle is undoubtedly taking place within the jars. Some of the carbon dioxide resulting from the oxidation of organic matter in the soil (the only source of organic matter under the conditions of the experiment) is converted into the organic matter of the plants, a part of which may again be liberated by the oxidation of this sloughed-off material. Thus a part of the solar energy absorbed by the plants may indirectly be utilized by the soil organisms during the growth period of the plants. Obviously, this additional amount of energy could not be supplied to the microorganisms of the uncropped soil and this may explain, in part, why less carbon dioxide is produced therein. The extra amount of available organic food which is supplied to the microorganisms by the growing plant may cause them to oxidize and mineralize more of the original supply of organic matter in the soil and make it available to the plants. This increased production of available nutrients may, in turn, result in increased plant growth. Thus these experiments appear to demonstrate a symbiotic relation between growing green plants and the oxidizing flora of the soil.

In this connection it is interesting to note that in the latest revision of his monograph on soil conditions and plant growth, Russell (2) devotes a special chapter to investigations indicative of the influence of growing plants upon biological action in the soil, and concludes with the statement that "there appears to remain only the possibility that the growing plant has a direct effect upon the decomposition processes going on in the soil. Unfortunately, field experiments alone do not enable us to decide this question and the systematic laboratory investigation has still to be undertaken."

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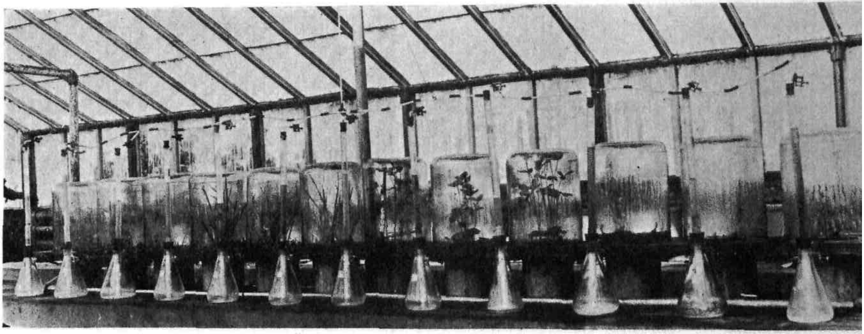
PLATE I.



Apparatus Used to Determine the Carbon Dioxide Evolved in Studying the Influence of Growing Plants Upon the Oxidizing Flora of the Soil. Jars Planted with Soybeans and Barley are in the Center, with Unplanted Control Jars at Each End.

THE EFFECT OF AMMONIUM SULFATE UPON THE AVAILABILITY OF IRON IN NUTRIENT SOLUTIONS

LINUS H. JONES

During the year research was undertaken to study the effect of ammonium sulfate on plant growth and its effect on the medium in which the plants were grown. Only partial results are available at the present time, but these appear to have special significance in connection with the use of iron in water cultures.

The procedure has been along the line of water-culture work in which an attempt has been made to substitute ammonium sulfate for potassium nitrate in Tottingham's nutrient solutions (3). Two experiments have been carried out, each comprising two series of cultures, which will be referred to as the Tottingham series and the ammonium sulfate series. The Tottingham series of solutions as here used comprised 20 representative solutions, chosen from Tottingham's complete series of 84. The twenty solutions chosen are uniformly distributed in the series and include all the solutions designated by odd numbers which are comprised in the odd rows of the odd triangles according to the system of numbering the solutions and the diagrammatic scheme adopted by Tottingham to express concretely the relative salt proportions of the various solutions. The ammonium sulfate series was the same as the Tottingham series in every respect except that ammonium sulfate in equal osmotic concentrations was substituted in place of the varying increments of potassium nitrate in the Tottingham series. These solutions were made up so that they would have a calculated total osmotic concentration value of one atmosphere. Freezing-point determinations showed that this concentration was closely approximated in the solutions.

The plants used were spring wheat of the "Marquis" variety. Three plants made up a culture and these were grown in quart fruit jars. The solutions were renewed every 3½ to 4 days and at the time of each renewal of solutions the loss of water through transpiration was measured and the hydrogen-ion concentration of the solutions determined by the colorimetric method, with the standard buffer mixtures and the indicators recommended by Clark and Lubs (1).

Experiment I

In preparing the nutrient solutions for this experiment, iron was added to each solution of the two series in the form of a semi-colloidal suspension of ferric phosphate. A sufficient amount of this suspension was added to each solution to provide 0.000814 gm. of iron per liter of solution. At the beginning of the third week of growth the

plants in some of the cultures of the Tottingham series began to show a yellow appearance and this later became quite general throughout the series. At the time of harvesting, the plants in most of the cultures of this series were very chlorotic. On the other hand, the plants in all the cultures of the ammonium sulfate series were very green, thrifty and apparently healthy. There was no evidence of the lack of chlorophyll which characterized the plants of the Tottingham series.

At the end of the 5-week period of growth the plants were harvested and the dry weights of the tops and roots obtained. The total weights of tops only will be considered in this preliminary report. The experiment was repeated with similar results, but on account of the fact that the plants suffered an attack of mildew, it was deemed best not to make use of the data obtained. In table 1 are given the total dry weights of the highest five cultures of each of the two series.

TABLE 1

Total dry weights of the highest five yields of wheat from the Tottingham series and the highest five from the ammonium sulfate series, the source of iron for the plants in each series being ferric phosphate

Tottingham Series		Ammonium Sulfate Series	
Culture Number	Dry Weight	Culture Number	Dry Weight
	gm.		gm.
$T_7R_1C_1$	1.6055	$T_1R_1C_5$	2.9159
$T_5R_3C_1$	1.4839	$T_1R_1C_3$	2.8364
$T_3R_1C_3$	1.3986	$T_3R_1C_5$	2.4759
$T_2R_1C_1$	1.3559	$T_1R_3C_5$	2.3766
$T_5R_2C_1$	1.3472	$T_3R_3C_1$	2.1455
Average	1.4382	Average	2.5501

From table 1 it will be observed that the highest five yields from the ammonium sulfate series are all much superior to the corresponding yields from the Tottingham series, the average of the high yields from the former being 77 per cent higher than that from the latter. The chlorotic condition of the plants in the Tottingham solutions which resulted in greatly decreased yields was clearly due to the inability of the plants to get sufficient iron for their needs from the insoluble ferric phosphate in the solutions, since this chlorotic condition was entirely overcome in the plants of duplicate cultures by adding to the solutions at the time of renewal ferrous sulfate instead of ferric phosphate, the amounts of iron per liter of nutrient solution

always being the same. The plants of the solutions so treated recovered their normal green color in the course of a few days.

A study of the hydrogen-ion concentration data brought out the fact that it was the tendency of the Tottingham solutions to become less acid during the intervals between the renewal of the solutions. From an original pH value of 4.7 they changed to a pH value of about 5.8 during an interval of 3½ days at about the fourth week of growth. With the ammonium sulfate series the reverse was true. The solutions became more acid during the same interval, changing from a pH value of 4.8 to one of about 4.2.

The plants were scored for yellowness in accordance with a relative score method for comparing plant conditions adopted by Free (2) and the values thus obtained were plotted in a graph which was compared with the graph of dry weights and with a graph similarly plotted, representing the changes in the pH values of the solutions in which the plants were growing during an interval of 3½ days near the end of the growth period. This comparison brought out the fact that in the solutions which showed the greatest change in pH values toward the neutral point, the chlorotic condition of the plants was most pronounced and the dry weight yields were the lowest. The ferric phosphate is probably more soluble in solutions having a higher hydrogen-ion concentration and this may account for the fact that the plants in the series of ammonium sulfate solutions were enabled to obtain sufficient iron to prevent chlorotic effects during the early stages of growth covering a period of 5 weeks from the time when they were placed in the nutrient solutions.

Experiment II

This experiment was carried out in precisely the same manner as was the preceding one, but instead of using the insoluble ferric phosphate as the source of iron for the plants, ferrous sulfate was added to the solutions of both series. A sufficient amount of this salt in solution form was supplied to each liter of nutrient solution to provide the same amount of iron (0.000814 gm.) as was used in the form of ferric phosphate per liter of nutrient solution in the preceding experiment. The solutions were renewed as before and the two series of cultures were again conducted during a growth period of 5 weeks.

At the end of 3 weeks it was noticeable that the plants in the cultures of the ammonium sulfate series did not stand up as well as those in the cultures of the Tottingham series. The plants were dull in color as compared with the healthy green color of the plants in the Tottingham series, although there was no evidence of any distinctly chlorotic effects. This apparent sickness gradually increased in intensity and at the end of the growth period the leaves of some plants showed very narrow white stripes which had the appearance of being

completely bleached of all coloring matter. All the plants in this series drooped, while those in the Tottingham series stood erect and gave every evidence of being in a healthy, vigorous condition.

At the end of the growth period the plants were harvested as before and the dry weights of tops and roots obtained. In table 2 are given the total dry weights of the highest five yields from each of the two series.

TABLE 2

Total dry weights of the highest five yields of wheat from the Tottingham series and the highest five from the ammonium sulfate series. the source of iron for the plants in each series being ferrous sulfate

Tottingham Series		Ammonium Sulfate Series	
Culture Number	Dry Weight	Culture Number	Dry Weight
	gm.		gm.
$T_1R_3C_3$	4.1134	$T_2R_1C_1$	1.5530
$T_3R_5C_1$	4.0549	$T_3R_1C_1$	1.2521
$T_1R_2C_3$	4.0271	$T_3R_1C_4$	1.1722
$T_3R_1C_5$	3.8869	$T_2R_3C_1$	1.0745
$T_7R_1C_1$	3.7821	$T_1R_1C_1$	1.0740
Average	3.9729	Average	1.2252

As table 2 shows, the highest five yields from the Tottingham series are all greatly superior to the corresponding yields from the ammonium sulfate series. The average of the high yields from the former is 224 per cent above that from the latter. These results are just the reverse of those obtained with the preceding experiment, as the data in table 1 show.

The use of iron in the form of ferrous sulfate in the small amounts here employed *(0.000814 gm. of iron per liter of nutrient solution)* proved to be very toxic to the plants in the solutions of the ammonium sulfate series, while the plants in the solutions of the Tottingham series suffered no ill effects, maintained a healthy green color throughout the entire growth period and made excellent growth.

It is thus evident that given forms of iron in fixed small amounts are not equally efficient in different nutrient media for plant growth. The ferric phosphate in the small quantities here employed proved entirely inadequate in the Tottingham solutions, but gave good results when the potassium nitrate in the Tottingham solutions was replaced with ammonium sulfate. On the other hand, ferrous sulfate gave excellent results with the Tottingham solutions, but proved very

toxic when similarly used with the solutions of the ammonium sulfate series. It appears, therefore, that the "usual trace" of iron may be very efficient with respect to plant production in some media, and may be toxic or entirely inadequate in others.

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A STUDY OF THE SALT REQUIREMENTS OF THE POTATO

W. H. Martin and J. W. Shive

It was the purpose of this study to determine the salt combinations required for the maximum development of tubers, tops, and roots of the potato. This report states in a very brief manner some of the results of the work thus far carried out. A more complete presentation of the results will follow as the work progresses.

The work was performed with the Green Mountain variety of potatoes grown in sand. Salts in the form of solutions of the same initial total concentration of approximately 1.0 atmosphere were applied to the sand to produce a moisure content of 16 per cent of the air-dry sand. The salts were so distributed as to include all possible sets of salt proportions for increments of change equal to one-eighth of the total concentration, thus providing 21 different sets of salt proportions of the three component salts, KH_2PO_4, $Ca(NO_3)_2$, and $MgSO_4$, for the concentration employed. The solutions here used were the same as those designated as type I in "A plan for cooperative research on the salt requirements of representative agricultural plants" adopted by a special committee of the National Research Council. A table of the partial volume-molecular concentrations and molecular proportions of the salts is given in the publication (2) referred to.

The culture vessels consisted of glazed earthenware jars, each of which held 4.5 kgm. of sand when filled to within about 8 cm. of the top. When tubers began to form and increase in size, they showed a tendency to push up through the sand. When this occurred, an additional 720 gm. of sand was added to each culture.

The solutions were changed every seventh day, the method employed being essentially that devised by McCall (3) and later modified by

Shive (5). At the end of every 2 or 3-day period, each pot was weighed and a sufficient amount of distilled water added to restore it to its original weight.

All the seed potatoes used in any series were from a single hill, selected the previous year for vigor and freedom from disease. The tubers were cut transversely into slices from 1 to 2 inches thick, the cut being made in the vicinity of an eye. The cut pieces were then placed in moist sand to germinate. When sprouts from 2 to 4 cm. long with vigorous root systems had developed, they were removed from the germinating chambers and the adhering sand was washed from the roots in distilled water. This method adopted for the germination of tubers and for securing vigorous sprouts proved very satisfactory. The sprouts with their roots were then removed from the seed-pieces. The majority of sprouts selected were taken from the terminal end of the tubers. In several instances it was found necessary to take them from the vicinity of the stem end. It is doubtful, however, if the position of the sprouts on the tuber had any influence on yield, since Appleman (1) has shown that if the terminal eyes are removed, the eyes on the stem end show a capacity for the production of vigorous sprouts equal to that of the terminal eyes, if not greater. After the sprouts had been removed, those carefully selected for uniformity of size and vigor were placed in sand cultures which had previously been prepared in such a way as to allow for the renewal of nutrient solutions during the growing period.

When the vines in the different cultures had matured, they were severed from the roots at the surface of the sand and placed in weighing bottles. They were then dried to constant weight in an electric oven and the dry weights secured. The tubers were likewise removed, cut into slices and dried. The roots were washed out from the sand and together with adhering particles of sand were placed in weighing bottles, but since the dry weights have not yet been obtained they will not be included in this report.

A duplicate series of cultures was conducted from March 9 to June 2. The data presented represent the average yields from the two series. For the purpose of comparison, two control cultures prepared with Shive's (4) three-salt solution number R^5C^2 were included in each series. The dry weights of both tops and tubers from these two cultures were nearly the same in value, which is an indication that large variations in the yielding power of similar sprouts from different parts of the same tuber perhaps are not to be expected.

For the sake of brevity, only the highest six yields of both tops and tubers will here be considered. The numerical data of these yields, together with the partial volume-molecular concentrations of the solutions producing them, are presented in table 1.

From table 1 it is observed that three of the cultures which produced high yields of tops produced also high yields of tubers. The maximum yield of both tops and tubers was produced by the same

culture, the three salts, KH_2PO_4, $Ca(NO_3)_2$, and $MgSO_4$ being present in this culture in the molecular proportion of 0.0022, :0.0089, :0.0067.

The six cultures which produced high yields of tubers show a wide range in the proportions of KH_2PO_4, this range extending from 0.0022*m* to 0.0123*m*, while the six cultures which produced high yields of tops have a corresponding range embracing relatively low proportions of this salt and extending only from 0.0022*m* to 0.0068*m*. This appears to indicate that the salt in question may not be very definitely related to the production of high yields of tubers since these

TABLE 1

The highest six average yields of potato tops and tubers, and the corresponding volume-molecular salt concentrations, from a complete series of 21 cultures

Culture number*	Partial volume-molecular concentrations			Dry weights	
	KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$	Tops	Tubers
R^1C^4	.0022	.0089	.0067	5.177	11.954
R^2C^4	.0045	.0090	.0045	4.206	......
R^3C^3	.0068	.0068	.0045	4.195	10.033
R^1C^5	.0022	.0108	.0043	4.127	......
R^2C^2	.0049	.0049	.0069	4.114	9.517
R^2C^3	.0047	.0071	.0071	4.099	......
R^3C^2	.0072	.0048	.0072	.....	10.514
R^5C^2	.0118	.0047	.0023	.....	9.458
R^5C^1	.0123	.0024	.0049	.....	9.450

*The culture numbers refer to the positions which the cultures occupy in the series with respect to the triangular diagram graphically representing the variations in the salt proportions of the solutions here employed. For a description of this diagramatic scheme see (2).

yields are associated with the lowest proportions as well as high proportions of this salt. On the other hand, KH_2PO_4 is quite definitely related to the production of high top yields, only low proportions of this salt corresponding to high yields.

The proportions of $Ca(NO_3)_2$ and $MgSO_4$ which are associated with high yields of tubers extend over relatively small ranges and are therefore well defined, and with the exception of one or two cultures this is true also with respect to the proportions of these two salts which produced high yields of tops. In the cultures of these series high yields of both tops and tubers are associated, in general, with intermediate proportions of the two salts $Ca(NO_3)_2$ and $MgSO_4$. On the whole, it appears that the salt proportions which

produced high yields of tops are more definitely defined than are those which produced high yields of tubers.

It is interesting here to note that nearly all the cultures which produced low yields of tops and tubers were characterized by having high proportions of one of the three component salts and correspondingly low proportions of the other two.

It is to be emphasized that the results here briefly summarized represent merely the beginning of these studies, and that the data thus far obtained are, of course, not sufficient upon which to base any definite conclusions. This work will be continued and it is to be hoped that in time a fairly accurate measure of the salt requirements of the potato may be obtained for a given set or sets of experimental conditions.

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REPORT OF THE DEPARTMENT OF ENTOMOLOGY

Department of Entomology

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*Resigned June 30, 1920.

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Report of the Department of Entomology

THOMAS J. HEADLEE

INTRODUCTION

As in previous years the attention of the entomologist and his staff has been given to: (1) the furnishing of information concerning the nature and control of injurious and beneficial insects in response to direct request by the citizens of the state; (2) the preparation of bulletins and circulars setting forth the results of investigations of insects injurious and beneficial to the agricultural and urban life of the state; (3) the investigation of insects injurious to agricultural, industrial and urban life; (4) the prosecution of studies relative to the growing of cranberries; (5) studies on the proper disposal of human sewage and (6) the control of the mosquito pest.

Miss Augusta Meske, assisted by Miss Margaret V. Fross, has conducted the clerical work of the office; Dr. Alvah Peterson has devoted his attention to the investigation of peach borer and rose typophorus; Dr. Mitchel Carroll has devoted his attention to the question of mosquito control and Charles S. Beckwith has divided his time between mosquito-control problems and cranberry culture. J. W. Thomson, as fellow in the department, has devoted his attention to certain problems in connection with sewage disposal.

CORRESPONDENCE

The correspondence this year has required the preparation of about 7,000 letters. Inquiries concerning 170 different species of insects, summarized in the following list, have been received and attended to.

Arachnida

Latin Name	Common Name	Locality	Date
Argiopoidea sp.	Spider	Somerville	Sept. 29, '19
Aleurobius farinæ sp.	Mites	Caldwell	Oct. 8,
Eriophyes sp.	Mite	New York, N. Y.	Sept. 22,
Eriophyes sp.	Mite	Morris Plains	Aug. 18,
Eriophyes pyri Pgst.	Pear leaf blister mite	Oxford	May 27, '20
Eriophyes pyri Pgst.	*Pear leaf blister mite*	*Hackensack*	*June 26, '19*
Misumena sp.	Crab spider	Morristown	Oct. 8,
Tetranychus bimaculatus Harv.	Red spider	Hackensack	Aug. 25,

Myriapoda

Latin Name	Common Name	Locality	Date
	Thousand-legged worm	Madison	Aug. 4,
	Thousand-legged worm	Bordentown	Mar. 16, '20

Insecta

Thysanura

Latin Name	Common Name	Locality	Date
Thermobia domestica Pack.	Fish moth	Paterson	Feb. 26,

Thysanoptera

Latin Name	Common Name	Locality	Date
Thripidæ	Thrips	Elizabeth	Sept. 22, '19

Homoptera

Latin Name	Common Name	Locality	Date
Aleyrodes vaporariorum Westrw.	Greenhouse white fly	Little Silver	Feb. 26, '20
Aphididæ sp.	Plant lice	Bordentown	Mar. 16, '20
Aphididæ sp.	Plant lice	Lyndhurst	Mar. 4,
Aphididæ sp.	Plant lice	Tenafly	June 29,
Aphididæ sp.	Plant lice	New Brunswick	June 26,
Aphis sp.	Plant lice	Long Branch	Oct. 4, '19
Aphis sp.	Plant lice	National Park	Sept. 19,
Aphis sp.	Plant lice	Plainfield	Sept. 25,
Aphis sp.	Plant lice	Morristown	July 1,
Aphis sp.	*Plant lice*	*Hulmeville, Pa.*	*July 11, '19*
Aphis sp.	Plant lice	Perth Amboy	Sept. 11, '19
Aphis sp.	Plant lice	Haddonfield	Sept. 19, '19
Aphis sp.	Plant lice	Haddonfield	July 14, '19
Aphis sp.	Plant lice	Winslow	July 16,

Homoptera—(Continued)

Latin Name	Common Name	Locality	Date
Aphis maidi-radicis Forbes	Corn root aphis	Franklinville	Mar. 5, '20
Aphis pomi. DeG.	Green apple aphis	Perth Amboy	May 14,
Aphis pomi. DeG.	Green apple aphis	Allendale	Nov. 11,
Aphis pomi. DeG.	Green apple aphis	Westwood	Jan. 21,
Aphis pomi. DeG.	Green apple aphis	Summit	Jan. 5,
Aphis pomi. DeG.	Green apple aphis	Woodbury	Feb. 17, '20
Aphis pomi. DeG.	Green apple aphis	Wharton	Mar. 11,
Aphis pomi. DeG.	Green apple aphis	New York City	Sept. 5, '19
Aphis pomi. DeG.	Green apple aphis	Chatham	July 11,
Aspidiotus perniciosus Comst.	San José Scale	Cedarville	Jan. 5, '20
Aspidiotus perniciosus Comst.	San José Scale	Gloucester	June 18,
Ceresa bubalus Fab.	Buffalo tree hopper	New Brunswick	Jan. 14,
Chermaphis pinicorticis Fitch	Pine bark aphid	Morristown	July 1, '19
Chermaphis pinicorticis Fitch	Pine bark aphid	New York City	Oct. 22,
Chionaspis furfurus Fitch	Scurfy scale	Merchantville	Feb. 27, '20
Chionaspis pinifoliæ Fitch	Pine needle scale	Bernardsville	July 14, '19
Chionaspis pinifoliæ Fitch	Pine needle scale	Clifton	Sept. 16,
Cicada sp.	Cicada	Somerville	Aug. 16,
Cladobius salicti Harr	Willow aphis	Montclair	Oct. 27,
Colopha ulmicola Fitch	Coxcomb elm gall	Toms River	June 28, '20
Eulecanium nigrofasciatum Perg.	Terrapin scale	Mount Holly	Oct. 21, '19
Eulecanium nigrofasciatum Perg.	Terrapin scale	Hightstown	Feb. 11, '20
Euleucanium tulipiferæ Cook	Tulip soft scale	Maplewood	Sept. 22, '19
Euleucanium tulipiferæ Cook	Tulip soft scale	Woodbury	Oct. 22,
Jassoidæ sp.	Leaf hopper	New York City	July 11,
Jassoidæ sp.	Leaf hopper	Newark	Sept. 26,
Jassoidæ sp.	Leaf hopper	Belle Meade	July 15,
Jassoidæ sp.	Leaf hopper	Millstone	July 22,
Lachnus sp.	Plant lice	Camden	Nov. 6,
Lachnus sp.	Plant lice	Atlantic City	Nov. 3,
Lepidosaphis ulmi, Linn.	Oyster shell scale	Nutley	Nov. 17,
Macrosiphum solanifolii Ashm.	Potato aphis	Linden	July 24,
Macrosiphum solanifolii Ashm.	Potato aphis	Ithaca, N. Y.	July 9,
Macrosiphum solanifolii Ashm.	Potato aphis	Ithaca, N. Y.	July 7,
Membracidæ sp.	Tree hoppers	Millstone	July 22,
Phenacoccus acericola King.	Currant aphis	Oxford	May 27, '20
Myzus ribis Linn.	False maple scale	Keyport	Sept. 8, '19
Phenacoccus acericola King.	False maple scale	Woodbury	Sept. 9,

Homoptera—(Continued)

Latin Name	Common Name	Locality	Date
Phenacoccus acericola King.	False maple scale	Millburn	Sept. 1,
Phenacoccus acericola King.	False maple scale	Washington	Aug. 4,
Phenacoccus acericola King.	False maple scale	South Orange	Aug. 14,
Phenacoccus acericola King.	False maple scale	South River	Aug. 22,
Phenacoccus acericola King.	False maple scale	Maplewood	Aug. 4,
Phylloxera caryea-caulis Fitch	Hickory gall louse	New York City	Sept. 22,
Phylloxera caryea-caulis Fitch	Hickory gall louse	Greenwich	June 11, '20
Phylloxera caryea-caulis Fitch	Hickory gall louse	Englewood	June 21,
Pseudococcus sp.	Mealy bugs	Woodbury	Aug. 21, '19
Psylla pyricola Forst.	Pear psylla	Moorestown	Oct. 10,
Psylla pyricola Forst.	Pear psylla	Moorestown	Oct. 4,
Psylla pyricola Forst.	Pear psylla	Marlton	Oct. 8,
Psylla pyricola Forst.	Pear psylla	Burlington	April 17, '20
Psylla pyricola Forst.	Pear psylla	Riverton	Mar. 22,
Psylla pyricola Forst.	Pear psylla	Toms River	Mar. 12,
Psylla pyricola Forst.	Pear psylla	Burlington	May 12,
Pulvinaria innumerabilis Rathv.	Cottony maple scale	Asbury Park	Aug. 7, '19
Pulvinaria innumerabilis Rathv.	Cottony maple scale	Asbury Park	July 3,

Hemiptera

Latin Name	Common Name	Locality	Date
Tibicen septendecim Linn.	17-year cicida	Pattenbury	Mar. 26, '20
Tibicen septendecim Linn.	17-year cicida	Toms River	Sept. 25, '19
Tibicen septendecim Linn.	17-year cicida	Flemington	July 26, '19
Tibicen septendecim Linn.	17-year cicida	Morris Plains	Aug. 8,
Tibicen septendecim Linn.	17-year cicida	Hightstown	July 21,
Leptobyrsa rhododendri Horv.	Rhododendron lace bug	Plainfield	Sept. 5,

Orthoptera

Latin Name	Common Name	Locality	Date
Acrididæ sp.	Grasshoppers	Elmira, N. Y.	July 25,
Acrididæ sp.	Grasshoppers	Princeton	July 11,
Blattidæ sp.	Cockroaches	Plainfield	Jan. 28, '20
Blattella germanica Linn.	German cockroach	Woodstown	July 8, '19
Gryllotalpa borealis Burn.	Mole cricket	New Brunswick	Aug. 25,
Microcentrum rhombifolium Saus.	Common katydid	Haddonfield	April 29, '20
Oecanthus angustipennis Fitch	Narrow-winged tree cricket	Bordentown	Nov. 12, '19
Lygus pratensis Linn.	Tarnished plant bug	Millstone	July 22,
Lygus pratensis Linn.	Tarnished plant bug	Belle Meade	July 15,

Coleoptera

Latin Name	Common Name	Locality	Date
Agrilus ruficollis Fab.	Blackberry gall maker	Moorestown	Feb. 27, '20
Amphicerus bicaudatus Say.	Apple twig borer	Montvale	April 29,
Anomala lucicola Fab.	Light-loving grapevine beetle	Salem	July 3, '19
Anthonomus signatus Say.	Strawberry weevil	Brooklyn, Md.	Feb. 26, '20
Anthonomus signatus Say.	Strawberry weevil	Salem, N. J.	Jan. 6,
Anthonomus signatus Say.	Strawberry weevil	Haddonfield	April 12, '20
Anthonomus signatus Say.	Strawberry weevil	Vineland	Mar. 12,
Anthonomus signatus Say.	Strawberry weevil	Bridgeton	April 17,
Anthonomus signatus Say.	Strawberry weevil	Knoxville, Tenn.	July 20, '20
Balaninus rectus Say.	Chestnut weevil	Buena	Mar. 15,
Bruchus obtectus Say.	Bean weevil	Morristown	July 15, '19
Bruchus obtectus Say.	Bean weevil	South Orange	Oct. 9,
Bruchus obtectus Say.	Bean weevil	Stockton	July 16,
Calandra granaria Linn.	Granary weevil	Toms River	Sept. 26,
Carabidæ sp.	Ground beetle	Woodstown	July 8,
Cassida bivittata Say.	Gold bug	Caldwell	July 19,
Chrysochus auratus Fab.	Leaf feeding beetle	Tenafly	July 16,
Chrysomelidæ sp.	Flea beetles	Hulmeville, Pa.	July 11,
Chrysomelidæ sp.	Flea beetles	Belle Meade	July 15,
Coccinellidæ	Lady bird	Belle Meade	July 15,
Coccinellidæ	Lady bird	Chatham	July 11,
Lachnosterna sp.	White grubs	Burlington	Oct. 9,
Contrachelus nenuphar Hbst.	Plum curculio	Keansburg	July 12,
Contrachelus nenuphar Hbst.	Plum curculio	Barnegat City	Sept. 3,
Contrachelus nenuphar Hbst.	Plum curculio	West Summit	Sept. 17,
Contrachelus nenuphar Hbst.	Plum curculio	Grenloch	June 11, '20
Contrachelus nenuphar Hbst.	Plum curculio	Haddon Heights	Dec. 18, '19
Contrachelus nenuphar Hbst.	Plum curculio	Milford	June 8, '20
Contrachelus nenuphar Hbst.	Plum curculio	East Orange	July 1,
Contrachelus nenuphar Hbst.	Plum curculio	Somerville	June 24,
Dermestes lardarius	Larder beetles	New Brunswick	Nov. 14, '19
Diabrotica vittata Fab.	Striped cucumber beetle	Asbury Park	July 30,
Dicerca obscura Fab.	Flat headed borer	Summit	April 12,
Drasterius elegans Fabr.	Wire worms	Westwood	April 29, '20
Drasterius elegans Fabr.	Wire worms	Madison	July 13, '19
Epicauta marginata Fabr.	Margined blister beetle	Haddonfield	Aug. 5,
Epicauta marginata Fabr.	Margined blister beetle	Cape May	Aug. 11, '19
Epitrix cucumeris Harris.	Potato flea beetle	Lyndhurst	May 27, '20

Coleoptera—(Continued)

Latin Name	Common Name	Locality	Date
Euphoria inda Linn.	Bumble flower beetle	Haddonfield	Oct. 11, '19
Galerucella luteola Mull.	Elm beetle	Cranford	July 23,
Ips quadriguttatus Fab.	Beetle	Sea Bright	July 11,
Lachnosterna tristis Fab.	June bugs	Monmouth Junction	June 9, '20
Leptinotarsa decemlineata Say.	Colorado potato beetle	Ringoes	June 18,
Macrodactylus subspinosus Fab.	Rose bug	Philadelphia	July 8, '19
Macrodactylus subspinosus Fab.	Rose bug	Millville	July 23, '19
Macrodactylus subspinosus Fab.	Rose bug	Kingston	July 24,
Macrodactylus subspinosus Fab.	Rose bug	Kingston	July 21,
Macrodactylus subspinosus Fab.	Rose bug	Philadelphia	May 28, '20
Macrodactylus subspinosus Fab.	Rose bug	Lyndhurst	May 27,
Macrodactylus subspinosus Fab.	Rose bug	Grenloch	June 11,
Macrodactylus subspinosus Fab.	Rose bug	New Brunswick	June 21,
Macrodactylus subspinosus Fab.	Rose bug	Cedar Brook	June 21,
Macrodactylus subspinosus Fab.	Rose bug	Marlton	July 1,
Meloidæ sp.	Blister beetle	Nutley	Aug. 12, '19
Meloidæ sp.	Blister beetle	Caldwell	July 24,
Pissodes strobi, Peck.	White pine weevil	Morristown	July 1,
Silvanus surinamensis Linn.	Saw-toothed grain beetle	Silver Lake	Sept. 25,

Lepidoptera

Latin Name	Common Name	Locality	Date
Andricus punctatus Bass.	Gouty oak gall	East Orange	Aug. 26,
Archips rosaceana Harr.	Leaf-roller	West Hoboken	April 12,
Bembecia marginata Harris	Blackberry crown borer	Haddon Heights	Jan. 24, '20
Bucculatrix canadensisella Cham.	Birch leaf skeletonizer	Moorestown	Sept. 9, '19
Bucculatrix canadensisella Cham.	Birch leaf skeletonizer	Hammonton	Sept. 12,
Ceratomia catalpæ Bois.	Catalpa sphinx	Trenton	July 16,
Ceratomia catalpæ Bois	Catalpa sphinx	Paterson	Sept. 16, '19
Ceratomia catalpæ Bois	Catalpa sphinx	Bordentown	Sept. 12,
Coleophora vagans Sp.	Case bearers	Paterson	July 5,
Datana integerrima G & R	Black walnut caterpillar	Colonia	Aug. 5,
Datana integerrima G & R	Black walnut caterpillar	Hackensack	Sept. 2,
Datana integerrima G & R	Black walnut caterpillar	Sewell	Aug. 4,
Desmia funeralis Hbn.	Grape leaf folder	Roselle	Aug. 13,
Eulia pinatubana Kf.	Pine-tube moth	Millburn	Nov. 20, '19
Heliothis obsoleta Fab.	Corn ear worm	Newton	Nov. 4,
Heliothis obsoleta Fab.	Corn ear worm	Stockton	Oct. 31,
Heliothis obsoleta Fab.	Corn ear worm	Ridgefield	Oct. 27,

Lepidoptera—(Continued)

Latin Name	Common Name	Locality	Date
Heliothis obsoleta Fab.	Corn ear worm	Pasadena, Cal.	Dec. 30,
Heliothis obsoleta Fab.	Corn ear worm	New York City	April 12, '20
Heliothis obsoleta Fab.	Corn ear worm	Mount Holly	Aug. 20, '19
Heliothis obsoleta Fab.	Corn ear worm	Grenloch	Aug. 4,
Laspeyresia molesta Busck.	Oriental peach moth	Perth Amboy	Sept. 11,
Laspeyresia molesta Busck.	Oriental peach moth	Auburn, Ala.	Nov. 5,
Lepidoptera	Caterpillars	Linden	Aug. 2,
Lepidoptera	Caterpillars	Clifton	Sept. 16,
Lepidoptera	Moths	Pleasantville	Nov. 3,
Leucania unipuncta Haw.	Army worms	Brooklyn, N. Y.	Aug. 5,
Melitia satyriniformis Hbn.	Squash vine borer	New York, N. Y.	Feb. 26, '20
Melitia satyriniformis Hbn.	Squash vine borer	Moorestown	Mar. 11,
Melitia satyriniformis Hbn.	Squash vine borer	Lyndhurst	April 12,
Melitia satyriniformis Hbn.	Squash vine borer	Asbury Park	July 30, '19
Melitia satyriniformis Hbn.	Squash vine borer	National Park	Sept. 19,
Noctuidæ sp.	Cut worms	Milford	June 7, '20
Noctnidæ sp.	Cut worms	Lyndhurst	Mar. 4,
Papaipema nitella Gn.	Common stalk borer	Morristown	July 16, '19
Papaipema nitella Gn.	Common stalk borer	Woodbury	Feb. 26, '20
Papaipema nitella Gn.	Common stalk borer	Salem	July 3,
Papaipema nitella Gn.	Common stalk borer	Toms River	June 28,
Rapaipema nitelln Gn.	Common stalk borer	Newark	July 21,
Papaipema nitella Gn.	Common stalk borer	Collingswood	July 5,
Papaipema nitella Gn.	Common stalk borer	Atlantic City	Sept. 2,
Pieris rapæ Linn.	Cabbage butterfly	Lyndhurst	Mar. 4, '20
Pieris rapæ Linn.	Cabbage butterfly	Glen Gardner	June 30, '19
Plathypena scabra Fab.	Green clover worm	Westfield	April 12, '20
Plathypena scabra Fab.	Green clover worm	Toms River	Mar. 12,
Plathypena scabra Fab.	Green clover worm	New Market	Mar. 1,
Plathypena scabra Fab.	Green clover worm	Lyndhurst	Mar. 4,
Plathypena scabra Fab.	Green clover worm	Shiloh	Mar. 16,
Plathypena scabra Fab.	Green clover worm	Rahway	July 31, '19
Plathypena scabra Fab.	Green clover worm	Vineland	Aug. 1,
Plathypena scabra Fab.	Green clover worm	Westfield	Aug. 1,
Plathypena scabra Fab.	Green clover worm	Toms River	Aug. 8,
Plathypena scabra Fab.	Green clover worm	Nutley	Aug. 29,
Plathypena scabra Fab.	Green clover worm	Hampton	Aug. 7,
Plathypena scabra Fab.	Green clover worm	Cape May	Aug. 2,

Lepidoptera—(Continued)

Latin Name	Common Name	Locality	Date
Plathypena scabra Fab.	Green clover worm	Washington	Aug. 4,
Plathypena scabra Fab.	Green clover worm	Manasquan	July 30,
Plathypena scabra Fab.	Green clover worm	Plainfield	Aug. 1,
Plathypena scabra Fab.	Green clover worm	Bayonne	July 30,
Plathypena scabra Fab.	Green clover worm	Lyndhurst	Aug. 5, '19
Plathypena scabra Fab.	Green clover worm	Plainfield	Aug. 2,
Plathypena scabra Fab.	Green clover worm	Elizabeth	Aug. 7,
Plathypena scabra Fab.	Green clover worm	Asbury Park	July 31,
Plathypena scabra Fab.	Green clover worm	Bridgeton	July 31,
Plathypena scabra Fab.	Green clover worm	Pleasantville	July 30,
Plathypena scabra Fab.	Green clover worm	Tranquility	Aug. 4,
Plathypena scabra Fab.	Green clover worm	Mullica Hill	Aug. 4,
Plathypena scabra Fab.	Green clover worm	Hackettstown	Aug. 11,
Plathypena scabra Fab.	Green clover worm	Oak Tree	Aug. 1,
Plathypena scabra Fab.	Green clover worm	Clinton	Aug. 4,
Plathypena scabra Fab.	Green clover worm	Norma	July 31,
Plathypena scabra Fab.	Green clover worm	South Orange	Aug. 11,
Plathypena scabra Fab.	Green clover worm	Sewell	Aug. 4,
Plathypena scabra Fab.	Green clover worm	Highlands	Aug. 8,
Plathypena scabra Fab.	Green clover worm	Camden	Aug. 5,
Plathypena scabra Fab.	Green clover worm	Vineland	Aug. 1,
Plathypena scabra Fab.	Green clover worm	Branch Mills	Aug. 1,
Plathypena scabra Fab.	Green clover worm	Norma	July 5,
Plathypena scabra Fab.	Green clover worm	Washington	Aug. 4,
Plathypena scabra Fab.	Green clover worm	East Orange	Aug. 3,
Plathypena scabra Fab.	Green clover worm	Dunellen	Aug. 7,
Plathypena scabra Fab.	Green clover worm	Elmer	Aug. 2,
Plathypena scabra Fab.	Green clover worm	Bordentown	Aug. 7,
Plathypena scabra Fab.	Green clover worm	East Orange	Aug. 2,
Plathypena scabra Fab.	Green clover worm	Plainfield	Aug. 4,
Plathypena scabra Fab.	Green clover worm	Bernardsville	Aug. 13,
Plathypena scabra Fab.	Green clover worm	Newton	Aug. 2, '19
Plathypena scabra Fab.	Green clover worm	North Arlington	Aug. 14,
Plathypena scabra Fab.	Green clover worm	Lambertville	Aug. 16,
Plathypena scabra Fab.	Green clover worm	Barnegat City	Sept. 3,
Polychrosis viteana Clem.	Grape berry moth	Perth Amboy	Sept. 11,
Sanninoidea exitiosa Say.	Peach tree borer	Westfield	July 6,
Sanninoidea exitiosa Say.	Peach tree borer	River Edge	Aug. 7,

Lepidoptera—(Continued)

Latin Name	Common Name	Locality	Date
Sanninoidea exitiosa Say.	Peach tree borer	Reading, Pa.	Aug. 7,
Sanninoidea exitiosa Say.	Peach tree borer	Trenton	Aug. 12,
Sanninoidea exitiosa Say.	Peach tree borer	Haddonfield	Sept. 30,
Sanninoidea exitiosa Say.	Peach tree borer	Martinsville	Sept. 30,
Sanninoidea exitiosa Say.	Peach tree borer	Perth Amboy	Sept. 11,
Sanninoidea exitiosa Say.	Peach tree borer	Ridgefield Park	May 12, '20
Sanninoidea exitiosa Say.	Peach tree borer	Trenton	April 29,
Sanninoidea exitiosa Say.	Peach tree borer	Egg Harbor City	April 28,
Sanninoidea exitiosa Say.	Peach tree borer	Carbondale, Ill.	Mar. 8,
Sanninoidea exitiosa Say.	Peach tree borer	Minotola	Feb. 4,
Sanninoidea exitiosa Say.	Peach tree borer	Westfield	Jan. 19,
Sanninoidea exitiosa Say.	Peach tree borer	Plainfield	Nov. 4, '19
Sanninoidea exitiosa Say.	Peach tree borer	Elizabeth	Oct. 17,
Sanninoidea exitiosa Say.	Peach tree borer	Oradell	Oct. 23,
Sanninoidea exitiosa Say.	Peach tree borer	New York City	Nov. 6,
Sanninoidea exitiosa Say.	Peach tree borer	Lyndhurst	April 12, '20
Sanninoidea exitiosa Say.	Peach tree borer	Wrightstown	June 17,
Sanninoidea exitiosa Say.	Peach tree borer	Riverton	June 21,
Sanninoidea exitiosa Say.	Peach tree borer	Charlestown, W. Va.	June 29,
Sibine stimulea Clem.	Saddle back caterpillar	Elizabeth	Sept. 12, '19
Sibine stimulea Clem.	Saddle back caterpillar	Newark	Aug. 25, '19
Sibine stimulea Clem.	Saddle back caterpillar	Sewell	Sept. 9,
Thyridopteryx ephemeræformis Steph.	Bag worm	Palmyra	July 24,
Thyridopteryx ephemeræformis Steph.	Bag worm	Pedricktown	July 23,
Thyridopteryx ephemeræformis Steph.	Bag worm	Pitman	Aug. 12,
Thyridopteryx ephemeræformis Steph.	Bag worm	Woodbury	Sept. 8,
Thyridopteryx ephemeræformis Steph.	Bag worm	Bordentown	July 8,
Thyridopteryx ephemeræformis Steph.	Bag worm	Rancocas	April 9, '20
Tinea pellionella Linn.	Case-making clothes moths	Irvington	July 11, '19
Tinea pellionella Linn.	Case-making clothes moths	Red Bank	Aug. 20,
Tinea pellionella Linn.	Case-making clothes moths	Essex Fells	April 29, '20
Zeuzera pyrina Fab.	Leopard moth	New York City	July 7, '19

Hymenoptera

Apis mellifera Linn.	Honey bee	Montville	Feb. 18, '20
Apis mellifera Linn.	Honey bee	Glassboro	Feb. 11,
Apis mellifera Linn.	Honey bee	Brooklyn	Feb. 8,
Apis mellifera Linn.	Honey bee	New Brunswick	Feb. 17,

Hymenoptera—(Continued)

Latin Name	*Common Name*	*Locality*	*Date*
Apis mellifera Linn.	Honey bee	Burlington	Jan. 19,
Apis mellifera Linn.	Honey bee	Irvington	Jan. 25,
Apis mellifera Linn.	Honey bee	Brookside	Nov. 24, '19
Apis mellifera Linn.	Honey bee	Dunellen	Oct. 13,
Apis mellifera Linn.	Honey bee	Delanco	Nov. 3,
Apis mellifera Linn.	Honey bee	Ocean Gate	Jan. 5, '20
Apis mellifera Linn.	Honey bee	Rahway	April 12,
Apis mellifera Linn.	Honey bee	Bound Brook	Mar. 8,
Apis mellifera Linn.	Honey bee	Hopewell	Mar. 3,
Apis mellifera Linn.	Honey bee	Hackensack	Mar. 8,
Apis mellifera Linn.	Honey bee	Swedesboro	Mar. 2, '20
Apis mellifera Linn.	Honey bee	Stoneham, Mass.	Feb. 28,
Apis mellifera Linn.	Honey bee	Trenton	Feb. 21,
Apis mellifera Linn.	Honey bee	White House Station	Feb. 20,
Apis mellifera Linn.	Honey bee	Swedesboro	Mar. 12,
Apis mellifera Linn.	Honey bee	Stoneham, Mass.	Feb. 24,
Apis mellifera Linn.	Honey bee	White House Station	Feb. 24.
Apis mellifera Linn.	Honey bee	Trenton	Feb. 21,
Apis mellifera Linn.	Honey bee	Columbus	Mar. 20,
Apis mellifera Linn.	Honey bee	Laurel Springs	Mar. 12,
Apis mellifera Linn.	Honey bee	Newark	Mar. 11,
Apis mellifera Linn.	Honey bee	Brooklyn, N. Y.	Mar. 12,
Apis mellifera Linn.	Honey bee	Flemington	Mar. 27,
Apis mellifera Linn.	Honey bee	Matawan	Mar. 23,
Apis mellifera Linn.	Honey bee	Brooklyn, N. Y.	Aug. 12, '19
Apis mellifera Linn.	Honey bee	Bloomfield	Aug. 5,
Apis mellifera Linn.	Honey bee	Morristown	Sept. 12,
Apis mellifera Linn.	Honey bee	Paterson	Sept. 4,
Apis mellifera Linn.	Honey bee	Newark	Sept. 4,
Apis mellifera Linn.	Honey bee	Pompton Lakes	Aug. 8,
Apis mellifera Linn.	Honey bee	Tuckahoe	July 18,
Apis mellifera Linn.	Honey bee	Blairstown	July 21,
Eriocampoides limacina Retz	Pear slug	Burlington	Jan. 24, '20
Eriocampoides limacina Retz	Pear slug	Newark	Sept. 8, '19
Formicidæ sp.	Ants	South Orange	May 6, '20
Formicidæ sp.	Ants	Westwood	Jan. 21,
Formicidæ sp.	Ants	Morristown	Aug. 9, '19

Hymenoptera—(Continued)

Latin Name	*Common Name*	*Locality*	*Date*
Megarhyssa lunator Fab.	Long-tailed "Ichneumons"	East Orange	July 14, '19
Megarhyssa lunator Fab.	Long-tailed "Ichneumons"	Landing	Sept. 18,
Megarhyssa lunator Fab.	Long-tailed "Ichneumons"	Trenton	July 30,
Vespa sp	*Hornets*	*Westfield*	*Nov.* 9, '19
Chalcididæ	Chalcid flies	Haddonfield	Oct. 6,
Isosoma tritici Fitch	Wheat joint worm	Trenton	June 30,

Siphonaptera

Ctenocephalus canis Curt.	Dog flea	Freehold	Aug. 11, '19
Ctenocephalus canis Curt.	*Dog flea*	*New Brunswick*	*April* 26, '20

Diptera

Anopheles quadrimaculatus	Malarial mosquito	Millville	Aug. 6, '19
Chironomidæ	Midges	Caldwell	Oct. 7,
Culicidæ	Mosquitoes	Hebron Station, Me.	Feb. 26, '20
Culicidæ	*Mosquitoes*	*Harrisburg, Pa.*	*Aug.* 31, '19
Eristalis tenax sp.	Drone fly	Annandale	Aug. 27,
Mayetiola destructor Say.	Hessian fly	Somerville	Sept. 6,
Phorbia sp.	Maggots	South Vineland	Mar. 11, '20
Phorbia sp.	Maggots	South Vineland	Mar. 3,
Phorbia brassicæ Bouche	Cabbage maggot	Glassboro	May 13,
Phorbia brassicæ Bouche	Cabbage maggot	Medford	June 10,
Phorbia brassicæ Bouche	Cabbage maggot	Lyndhurst	Mar. 4,
Phorbia brassicæ Bouche	Cabbage maggot	Rocky Hill	June 18,
Phorbia brassicæ Bouche	Cabbage maggot	Hammonton	June 18,
Phorbia brassicæ Bouche	Cabbage maggot	Paterson	June 19,
Phorbia ceptorum Meade	Onion maggot	Toms River	Mar. 12,
Phorbia ceptorum Meade	Onion maggot	Monroeville	Mar. 23,
Phorbia ceptorum *Meade*	*Onion maggot*	*Perth Amboy*	*June* 9, '20
Phorbia ceptorum Meade	Onion maggot	Hammonton	June 18,
Rhagoletis pomonella Walsh.	Apple maggot	Toms River	Oct. 21, '19
Sciara sp.	Sciara army worm	Rutherford	May 25, '20

INSECTS OF THE YEAR

Orchard Plant Lice

It is a pleasure to be able to report not only that orchard plant lice were present in far less numbers than during any one of the past several years but that the least injurious of the three species has been predominant. The oat aphis has made up the great bulk of the infestation. A rather curious feature of the situation during the season of 1919 has been the reappearance in considerable numbers, of the green apple aphis during the latter part of the summer. This species devoted its attention principally to water-sprouts and the rapidly growing tips of young trees.

What may be the cause of this condition is not known but it is thought that low temperature may have reacted unfavorably on its natural enemies.

Without doubt the spraying for apple aphis this year has been better done than ever before, but it has still not reached the point when the average orchardist can escape injury from such a form as the rosy apple aphis. Wherever the delayed dormant spray was applied as outlined in Circular 116 and the trees were coated, aphis trouble has been eliminated. Coating is a condition that can be tested by eyesight and requires only a low-power magnifying glass to detect.

Vegetable Plant Lice

The serious injury done during the latter part of the summer of 1918 by the pink and green aphis of the potato was repeated during the similar period of 1919. With a few exceptions the growers, apparently, completely failed to control the insect.

The lice seem to appear as a comparatively small number of winged migrants, establish an infestation over a period of three weeks or more until the plants are lousy, doing about three-quarters of the damage before the growers see the necessity for action. Furthermore, by the time this period has been reached the plants have almost or quite met in the rows, giving not only a tremendous surface to cover, but making it impossible to avoid a certain amount of mechanical injury to the vines in passing through them. The repeated attacks of plant lice have caused the purchase of many excellent potato sprayers and a great increase in efficient treatment.

The keynotes to combatting these pests successfully appear to be: *right mixtures, right method of application,* and *right time of treatment.* All these points are covered in Circular 107.

Other vegetable plant lice were not so troublesome in 1919 as in 1918.

Pear Psylla

For the first time in several years, adequate protection from this very seriously injurious insect to pear culture has been obtained during the year just closing. The control obtained was such as to leave the crop unstained and fruit buds free from evidence of its work. Adults were killed during dormancy with miscible oils, eggs just before bloom opened with winter-strength commercial lime-sulfur and nymphs whenever they made their appearance with summer-strength commercial or self-boiled lime-sulfur.

Codling Moth

The bad record made by this old and well-known insect last year was fully duplicated this year. Never in the 13 years of the entomologist's practical experience has he seen the codling moth as abundant. Many unsprayed trees lost 100 per cent of the fruit and many of the apples showed the work of several worms. Some of the largest orchardists in the state completely failed to obtain satisfactory control. The great prevalence of this insect seemed to center in lower Burlington, Camden and Gloucester counties. North of Mt. Holly and along the eastern seaboard the problem of control did not seem so difficult and excellent control was obtained. But even in the midst of the worst infested district there were growers who obtained good control.

Failure to obtain control seemed to be due to the failure to administer and maintain spray coating during the periods when the larvæ of the first and second brood are trying to enter the apples. The blossom-fall spray appeared to give adequate protection to the blossom ends of the apples under the most trying conditions. As codling moth conditions now stand in the most heavily infested regions, its control involves a type of spraying not hitherto practiced. The details of the studies made of this problem are set forth in a special section of this report.

Oriental Peach Moth

This imported insect has not made much progress or done much material damage in the area which it now covers. Dr. Peterson has been giving the matter of its artificial control special attention, and discusses it in a special section of this report.

Green Clover Worm

The green clover worm, which is a slender pale green caterpillar about 1 inch long when fully grown, appeared in large numbers on

all kinds of beans in all parts of the state during the season of 1919, and destroyed a large portion of the plantings that were not protected.

As a result of special studies it was found that by prompt treatment with a mixture of powdered arsenate of lead and sulfur or lime (1 to 5) the damage could be promptly checked. Arsenate of lead in Bordeaux mixture or arsenate of lead in water to which twice the amount of freshly slaked stone lime had been added also was found to be effective. When applied as a dust it was found necessary to coat the plants thoroughly, striking the leaves both from above and from below, using not less than 30 pounds to the acre. When applied as a spray it was found necessary to use about 6 pounds of the powdered lead to 1 acre of plants.

The worms ceased serious feeding within a few hours after the applications were made but did not completely disappear until a period of four or five days had elapsed.

Paris green and lime and calcium arsenate and lime burned the foliage. Detailed experiments will be set forth in a special section of this report.

Corn Ear-Worm

This insect became seriously injurious to late sweet corn throughout the trucking sections and in comparatively few places was it satisfactorily controlled.

Potato Flea Beetle

This small black jumping beetle, which is about the size of the head of a pin and eats window-like holes in the leaves of many sorts of vegetable crops, has largely been allowed to work its will without effective interference. The reason lies in the fact that the insect will not feed on foliage where it has been coated with a foreign substance but will search industriously for areas that have not been covered. The grower finds it is difficult to effect and to maintain this type of coating.

There is reason to anticipate that this flea beetle will not be brought under effective control until a practical method of destroying it can be found.

Plum Curculio

This very important insect enemy of plum, cherry, peach, pear and apple culture is still uncontrolled in many orchards, although the key to its control appears to have been found. The period during which injury is done extends from the falling of the blossoms to about 4 weeks thereafter. The damage may be done within a few days at any

time within this period, or it may take place more or less throughout this time.

Its control on the slow-growing stone fruits is comparatively simple because the coating administered at the slipping of the shucks is lasting. On the more rapidly growing pome fruits, especially apple, the spray coating is quickly broken and places untouched by spraying mixtures quickly become exposed. The keynote to its control appears to lie in making enough careful sprayings to maintain the coating of the fruit throughout the period covered by its injury. The present spraying schedules (Circulars 116, 117, 118, 119 and 120) have been arranged with a view to meeting this requirement.

Strawberry Weevil

The strawberry weevil was apparently as abundant this year as last and the sulfur-lead treatment seemed to give satisfactory control wherever applied in the right time and in the right way. The Maryland station reported a considerable series of trials at the annual meeting of the Peninsula Horticultural Society this year, and the report showed excellent control with the sulfur-lead, much better than with anything else.

The Strawberry Root Worm

This leaf beetle (*Typophorus canellus* Linn.) has been increasing the range of depredations and now occurs in many of the rose-producing greenhouses of the east. It is a small black beetle, about 1/8 inch in length. It has proven itself a very serious obstacle to rose growing during the three years that the station has been acquainted with its work. It devotes its attention to the foliage, particularly the young tender portions, and may largely defoliate the entire plants, ruining completely the prospects for a paying crop.

In the greenhouse where it was first discovered in this state it has been reduced to almost a negligible minimum by persistent hand collections. It has thus far proven impracticable to poison the adults or to destroy the larvæ in the soil. The work done against this insect is set forth in a special section of this report.

Green Japanese Beetle

This imported insect apparently spread an average of 1.5 miles last year. It now covers an area of 15,000 acres. Although very abundant in certain parts of this area, it cannot be said to have done large economic damage. In some cases grape, plum and apple foliage were

skeletonized and corn was pretty well prevented from setting grain, but the fractional volume of damage was very small. If, however, with greatly increased numbers this same work should become general the damage would be large and the pest would assume first-class importance. In the judgment of the entomologist this insect has up to date merely demonstrated that it is potentially dangerous.

It was on this basis that the writer as state entomologist gave his attention to securing money and organizing the movement against it. Funds to the amount of $125,000 are now or soon will become available for the effort. A station for this work was established at Riverton two years ago and has recently been greatly enlarged. The work has been placed in the hands of John J. Davis, who operates with an advisory committee consisting of Dr. A. L. Quaintance, representing the Federal Bureau of Entomology, and Dr. Thomas J. Headlee, representing the New Jersey State Department of Agriculture.

In general the work against this insect involves prevention of spread by various means, discovering a satisfactory insecticide for the grub and for the adult, and the introduction of the creature's natural enemies from its original home, Japan.

The present season, 1920, should show whether its spread can be prevented and determine to a large extent later procedure. The station has not undertaken any phase of this problem, but has left the whole matter to the special force employed to carry on this work.

INVESTIGATIONS

Pear Psylla

The work against the pear psylla has been continued along the lines outlined in last year's report (1918-19) with particular emphasis on the summer treatment.

Following June 30, 1919, applications were made wherever the droplets of honey-dew appeared on the under-sides of the pear foliage. The material employed was commercial liquid lime-sulfur (Beaumé 33°) at the rate of 1 gallon to 40 gallons of water. If the weather at the time of application was hot, self-boiled lime-sulfur was substituted for the commercial. In any case powdered arsenate of lead was added at the rate of 1.5 pounds to each 50 gallons of the mixture. In some cases an attempt was made to meet the hot weather conditions and prevent burning of foliage and fruit by reducing the strength of the liquid concentrate by using 1 gallon to 50 or even 60 gallons of water. Furthermore, in some instances, atomic sulfur was substituted for the lime-sulfur.

There is no doubt that the liquid concentrate at the rate of 1 gallon to 40 gallons of water gave best results in proportion to the amount of

spray used. With self-boiled lime-sulfur it was necessary to make the treatment much more thorough to kill anywhere nearly so large a percentage of the psylla. The entomologist did not himself superintend the experiments with the reduced strength of the concentrate but is assured by the orchardist on whose place the regularly superintended experiments were carried out, that with complete thoroughness of application the destruction of the psylla was as great as the kill that could be obtained with self-boiled lime-sulfur, and that the foliage and fruit were left uninjured by the treatments. The data on the substitution of atomic sulfur for lime-sulfur are too conflicting and uncertain to permit one to draw reliable conclusions. The arsenate of lead was added for the sake of controlling side-worm injury by the codling moth, with startling results in the way of efficient control.

Regardless of types of material used it was applied from below in such a way as to insure complete coating of the under-sides of the leaves where the psylla was at work. In the particular blocks, where the work was superintended, the material was applied with a gun and solid cone nozzle under a pressure of 250 pounds. One man went ahead with a short hose and a spray-gun and covered the inside of the tree, while the other followed with a long hose and spray rod and covered the under-sides of the foliage borne by the projecting branches. The trees did not in any case exceed 20 feet in height and an excellent coating was obtained in this way. The upper-sides of the foliage were pretty well coated by the falling liquid.

By each treatment a brood was so reduced as to prevent damage to fruit, foliage and forming buds. The crop of nearly 40,000 baskets (which sold for from 90 cents up) was harvested free from staining with less than 1 per cent showing any insect or fungous injury, the leaves were unstained and the buds went into fall without the usual coating of black stain. In fact, one of the most gratifying results of the treatments was the fine large appearance and healthy brown color of the buds.

During the fall before all the leaves were off the weather became cold and the psylla were found clinging to the small twigs and branches so stiff that they could not move. As much of the orchard was sprayed with winter-strength soluble oil (Scalecide) as could be covered before the weather warmed up. Whenever the weather became right and the psylla were found as above set forth, the spraying of the orchard was continued. When winter finally came on the psylla completely disappeared from the small twigs and branches and spraying operations ceased. When the opening of spring brought the psylla out of the rough bark and the cold snaps caused them to cling to the smaller twigs and branches too stiff to move, spraying with soluble oil was again resumed and continued whenever conditions were favorable until the orchard was covered. In some seasons, even for the man who is pretty well equipped, covering the entire orchard when the psylla are

clinging stiffly to the smaller twigs and branches proves a difficult matter because the periods of weather during which the psylla are in the proper condition (clinging to the smaller twigs and branches too stiff with cold to move) may be too limited. In such cases the untreated part of the orchard must be left uncovered and control must be sought in the growing-season treatments.

By the time the flowers are just about ready to open, most but usually not all of the eggs have been laid on the small twigs and branches. In the week preceding the opening of the blossoms, the trees can still safely be sprayed with commercial lime-sulfur concentrate and the maximum number of eggs are exposed to destruction by this treatment. Thoroughness of coating appears to be the keynote, for only the eggs which are wetted are killed. Unfortunately, as indicated above, not all of the eggs have been laid at this time and some will subsequently be laid from which will come later broods, but this treatment does prevent the insect from doing serious harm during the blooming and setting period and, in fact, retards its appearance until toward the end of June.

The investigations of the last five years appear to have shown the following points distinctly:

(1) Pear psylla is an insect capable of ruining the pear crop year after year. It stains the foliage, causing early defoliation, stains the fruit, reduces the size of fruit, and so weakens the buds as largely to prevent the setting of the fruit.

(2) Scraping the rough bark from the trees during dormancy has little effect on abundance of the psylla during the following year.

(3) Dormant-season treatment with soluble oil markedly reduces the number of psylla during the fore-part of the growing season following.

(4) Dormant-season treatments given when the weather is warm enough for psylla to jump and fly is largely a waste of time and material.

(5) Dormant-season treatments given only when the psylla are found hanging to the twigs and small branches too stiff with cold to move are much more effective than those given at other times.

(6) Coating the trees with standard liquid lime-sulfur, 1 gallon to 9 gallons of water, appears to destroy every psylla egg hit and to afford protection to the tree during blossoming, setting and early growth.

(7) Coating the under-sides of the foliage with standard liquid lime-sulfur (33° Beaumé), 1 gallon to 40 gallons of water, whenever the droplets of honey-dew appear on the under-sides of the leaves, appears so to reduce the developing brood as practically to eliminate the damage which that brood would otherwise do.

(8) Standard liquid lime-sulfur at the strength recommended in (7) will, if applied in hot weather, scorch or burn severely both foliage and fruit. Self-boiled lime-sulfur may be substituted for the standard liquid, will not burn, but requires more thorough application than the standard liquid. It is possible but not yet sufficiently proven that higher dilutions of the standard liquid such as 1 gallon to 60 gallons of water, may do as a substitute for the greater strength (1 gallon to 40 gallons of water), when the weather is too hot to render the application of the latter advisable.

(9) When codling moth is very serious each summer spray for psylla, until the fruit is picked, should incorporate powdered arsenate of lead at the rate of 1½ pounds to each 50 gallons.

Codling Moth

The work against the codling moth during the past year involved a continuance of the brood study which ran from spring to June 30, 1919. The observations began on worminess during that period and the carrying out of certain spraying and dusting studies for its control.

The necessity for a more or less systematic study of this well-known insect is to be found in the fact that in the season of 1918 pretty nearly nine out of every ten orchardmen in the southern portion of New Jersey failed to obtain satisfactory control. Six or seven years ago this condition did not exist and the spraying methods during that time, instead of becoming worse, have grown decidedly more efficient. Furthermore, the orchardists have been kept abreast of the developments in our knowledge of the life-habits and control of this insect. Never during the twelve or thirteen years of his experience has the entomologist seen the codling moth so abundant on unsprayed trees. During the season of 1919 he saw it not only take every apple on certain well set trees, but he found in many cases two or even three worms in a single apple.

If the tremendous increase in numbers of the codling moth cannot be charged to decreased effectiveness in spraying, as the writer believes certain to be the case, and cannot be blamed upon some other change in orchard management, it seems obvious that we have to do with an instance of tremendous natural increase, almost, if not entirely, unaided by artificial means. This is not a surprising or unusual phenomenon in insect life. In fact, so well recognized is it that we are accustomed to say insect abundance, and consequently insect injury, travels in successive waves. A period of great abundance and consequently large damage constitutes the crest, while a period of small numbers and consequently little or no injury represents the trough of the wave. The period of years occupied by the crest and the trough will vary not only with each species of insect, but with the time and place where it occurs. The explanation for this periodicity in insect behavior is somewhat obscure, but enough data have already been secured relative to the habits of certain plant lice to indicate that it is due to the effect of the weather upon the relation existing between the injurious insect and its natural enemies, primarily its parasitic enemies. Among certain plant lice it is well known that reproduction takes place not at the maximum speed, but with sufficient celerity rapidly to develop the pest under temperatures that are too low to permit the particular parasitic enemies from making appreciable headway in developing. Consequently so long as the temperature remains at the favorable point in question the injurious plant lice are likely to form a pest and do serious harm. On the other hand, it is well known that when the temperature rises much beyond this point the parasite can develop with much greater rapidity than can the host, with the result that

the host is practically destroyed and its ability as an injurious form for the time being completely eliminated. Something of this kind may have happened with the codling moth. The parasites being unable to reproduce and work effectively for the past several years, have allowed the moth freedom to develop perhaps without interference.

Be the cause whatever it may, there is no doubt that the codling moth is today immensely more abundant than it was six or seven years ago, and also while there is no doubt that certain careful orchardists, even in the badly infested regions, are able to obtain satisfactory control, the vast majority are failing to secure adequate protection from the ravages of this insect.

With these facts in mind a study of the insect's habits, together with measures of control, was undertaken. Several significant features made their appearance in the course of this study. Practically no orchardist whose spraying methods were at all up-to-date failed to obtain a satisfactory control of end-worminess. Furthermore, personal observations by the writer on unsprayed trees indicate that entry by the first brood, instead of showing, as is usually the case, much more than one-half of the worms entering the apple from the blossom end, indicate that a comparatively small proportion enter from that point—that the vast majority of the worms of the first brood enter from the sides or aspects of the apple other than the blossom end. The writer is sorry that he discovered this peculiarity too late to make the systematic counts of the fruit and thus establish to the satisfaction of all concerned that this difference exists.

Another significant feature which developed was the appearance of *two distinct periods during which the so-called side-worms entered* the apples. The first came early in the season and the second late in the season. The first affected both early and late varieties and the second the late varieties only. Both the first and the second were very marked in the latitude of Glassboro and Maple Shade, while only the first was very marked in the latitude of New Brunswick.

Still another significant feature was the effect of spraying materials upon side-worm injury. The entomologist repeatedly observed that the prompt and thorough application of an arsenical spraying mixture resulted in immediate cessation of side-worm entry and that this cessation continued until the coating effected by the spray had been broken by the growth of the apples or washed off by the rains.

Brood Study

For the purpose of determining the number of broods of codling moth in badly infested regions, two orchards were secured, one at Maple Shade in Burlington County, about 5 miles northeast of the city of Camden, and the other at Glassboro in Gloucester County, about 20 miles southeast of Camden. Each orchard was located in a

large orcharding section. It was anticipated that the difference in location was sufficient to produce a slight difference in the life cycle of the insect, but the study showed distinctly that the seasonal cycle in each place was practically identical. The work at these two places was checked with observations made at New Brunswick. There appears to exist between the life cycle of the codling moth at New Brunswick on the one hand and Maple Shade and Glassboro on the other hand, a difference of about one week. At Maple Shade and Glassboro the adult moths began emerging about May 3, reached their maximum about June 1 and ceased about June 12. The second brood began emerging about July 8, reached maximum about July 29 and ceased September 1. The first-brood larvæ began entering the apples about June 1, reached maximum about June 25 and ceased about July 8. The second-brood larvæ began entrance about July 25, reached maximum about August 11 and ceased about September 15. The apple

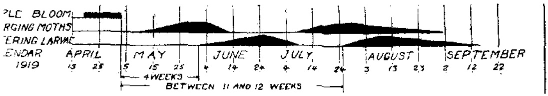

FIG. 1. DIAGRAM SHOWING THE TIME OF EMERGENCE OF BROODS OF CODLING MOTH AND THE ENTERING OF THE LARVÆ

bloom in general covered a period of nearly two weeks, the blossoms falling off the trees about May 3. From the falling of the petals until the beginning of entrance by the first-brood larvæ there was a period of about 4 weeks. From the falling of the bloom to the beginning of entrance by the second-brood larvæ there was a period of nearly 12 weeks. Figure 1 sets forth the number of broods developed, the period covered by the emerging moths and by the entering larvæ in relation to the falling of the apple blossoms. It thus appears that there were two full broods of codling moth in the Glassboro and Maple Shade sections of the state in the season of 1919.

Control

There seem to be three main problems of meeting the codling moth, as the entomologist has seen the problem in New Jersey. The first is concerned with the comparative value of the three sprays which are usually recommended for its control. The second is concerned with the type of material and the method of its application; and the third with finding the relation between the time that the spray should be applied and the development of the trees.

Relative Values of the Three Sprays

The studies made by Quaintance (5, 6) and his associates, Ball and his associates (1, 2), Melander (4) and Felt (3), nearly all of which have been carried out in regions of the United States not exactly comparable to that portion of the Coastal Plain including the southern half of New Jersey, indicate unmistakably that the first or blossom-fall spray is much more important than any other spray for the control of the codling moth. With the exception of instances where the above work was done under single-brood conditions, the idea seems to have been that the vast majority of the worms of the first brood enter the apples through the blossom end and are poisoned by the said spray, thus preventing the codling moth from producing a large second brood. Sanderson (7) presents a keen analysis of the results obtained up to the year 1909, and while he gave a place of first importance to the blossom-fall spray, he showed that the later sprays were also of large importance. If the writer's observations, as set forth earlier in this report, showing that a much larger percentage of the worms of the first brood enter the sides of the apples than has hitherto supposed to have been the case, may be assumed to be correct, the value of the first spray must be set materially lower than has hitherto been done. The entomologist knows no really good orchardist in the state who has failed to control his end-worminess, and he has observed on unsprayed trees that the amount of end-worminess, even under severe codling-moth conditions, has been relatively small. He is, therefore, inclined to think that the commonly accepted idea of the overwhelming proportion of codling moth larvæ of the first brood entering the blossom end, as has been shown to be the case by various investigators in different parts of the United States, does not at present hold for New Jersey conditions and that, therefore, the spray which is given at the blossom fall has not in the southern portion of this state the preeminent importance which has been attributed to it in other parts of the country. He does not wish to minimize the importance of this spray, but he rather wishes to emphasize the importance of later sprays.

There is absolutely no doubt in his mind that in the badly infested sections of the state failure to obtain satisfactory control of the side-worms of the first brood is absolutely certain to follow failure in having the fruit coated with the poisoned spray mixtures during the period that they are trying to enter. There is also no doubt whatever in his mind that in an orchard which is heavily infested, failure to have the fruit coated during the period that the second brood is entering the apples is certain to be followed by large damage.

As the matter now stands, it seems clear to the entomologist that in the badly infested parts of the state three sprays are absolutely essential to the satisfactory control of the codling moth. The first comes at the blossom fall and poisons the blossom end of the apple in such a way that worms entering through that point are destroyed. The second effects a complete coating of the fruit during the period that the worms of the first brood are trying to enter the apple and thus furnishes the dose of poison to practically every worm that tries to enter the aspects of the apple other than the blossom end. The third effects a coating of the fruit during the period that the worms of the second brood are trying to enter and destroys the young worms in exactly the same way as the second spray does.

Type of Materials and Methods of Application

Practically all studies of the materials used for controlling the codling moth in this country indicate that in an arsenical application the best type of material is found. Arsenate of lead by reason of its greater chemical stability and consequent freedom from injurious qualities to foliage and to fruit is now almost universally recommended for this purpose. The application of arsenate of lead either alone or in combination with a fungicide at the first, or blossom-fall, spray does not involve a factor of maintenance because the inside of the outer calyx cup which is poisoned at this time is protected from removal by weathering by reason of the well-known closing up habit of the apple calyx. In the second and third sprays, however, the factor of maintenance becomes exceedingly important, for the arsenate of lead, applied either alone or in combination with a fungicide, rests on the outside of the apple and is constantly subjected to being washed off by rains or being broken by the growth of the fruit. The factor of fruit growth is far more important in the second spray than in the third.

In the work of Sanderson (7) it is distinctly shown that a very considerable proportion of codling-moth larvæ are destroyed by arsenicals which are placed on the foliage and this is a factor which has not been adequately emphasized by most investigators of the subject. Fortunately, that type of application of spray material which insures a coating of the apple insures likewise a coating of most of the foliage, and as a rule the two factors have not been separated in the course of experimentation.

The experience of the entomologist during the season of 1919 has distinctly indicated that the secret to the control of the side-worms of the first and second broods lies in the maintenance of a thorough and complete coating of the apple fruit and foliage during the period that the worms are entering. Under practical conditions this coating cannot be given, especially to fruit and foliage on large trees, when

the spray is applied from above and the outside only. It seems to b absolutely necessary to spray the tree from inside and from below i order that these aspects of the apple may be reached and coated. Ex perience of the entomologist during 1919 also indicated that mos orchardists, even when furnished with an excellent equipment, do nc understand giving the above-described coating to the fruit and main taining it. There is too much of the feeling that the orchard operato cannot himself determine the efficiency of his work. He is too muc inclined to think that when he has passed by a tree, pointed the spray gun at it and thrown a lot of spray on it, the apples in some way ar sufficiently coated to prevent the work of the codling moth. In th mind of the orchardist the work of coating the apple necessary t prevent the work of the codling moth bears more or less of a "hokus pokus" character. This is due to the fact, apparently, that he ha never made it a practice to examine carefully his fruit to see the ex tent to which his treatment has actually coated it. There is som reason for this attitude, because to the naked eye only the spots wher large quantities of the material have settled and dried are easily visible When one takes a lens, however, one can tell pretty clearly and dis tinctly where the coating of material is on the apple surface and th extent to which this covered the surface of the apple. There are number of orchardists who have made a practice of studying the effec of their spray-guns and are able to tell where they have a coating, an those men, as a rule, are obtaining satisfactory control of the codlin moth found even in great abundance.

For the purpose of testing out the relative merits of arsenicals ap plied as a dust or as a spray for the control of the codling moth, a experiment was set in one of the badly infested districts. This ex periment was located in a block of large trees in a 250-acre appl orchard. The first block, consisting of 5 rows, was treated with a 85-15 mixture of finely divided sulfur and powdered arsenate of lead The first block as well as all the other blocks received the delaye dormant treatment for plant lice and scale insects. The dust applica tions were given at the pink bud stage, the blossom fall stage, 10 day after blossom fall, between June 20 and 30, and again about the thir week in July. The second block, consisting of 5 rows, was treate with a mixture of commercial lime-sulfur, 1 gallon to 40 gallons o water, to which arsenate of lead had been added at the rate of 1½ pounds to 50 gallons. The number and time of applications in thi block were the same as those set forth for the first block. On the thir block, consisting of 5 similar rows, the pink-bud, blossom-fall an 10-days-after-blossom-fall, sprays were made with the liquid as out lined for the second block. The treatment coming between June 2 and 30, and about the third week in July, were made with the dust mixture as outlined for block 1. All treatments were applied by th fruit grower on whose place the experiments were made. In takin

the data 5 trees from each block, chosen from the center of each row in each case, were selected. The orchard drops were not taken into consideration, but data were taken on the picked fruit and the windfalls. The trees chosen for the data taken were all Grimes Golden.

On block 1 (dust only) the first brood of codling moth damaged 15 per cent and the second brood 50 per cent. On block 2 (liquid only) the first brood of codling moth damaged 7.4 per cent and the second brood 22.9 per cent. On the liquid-dust block, or No. 3, the first brood of codling moth damaged 7.9 per cent and the second brood 22.7 per cent.

While the control obtained with the liquid was not at all satisfactory, it is plainly indicated that the liquid did much better work than the dust. Careful observations on these blocks throughout the season indicated unmistakably that the failure to obtain control on the liquid blocks was not due to end-worminess but was the result of a failure to apply a complete coating and maintain it during the period when the worms of the first and second broods were entering the apples. In evidence of these conclusions it may be said that no cases of injury were found on the apple surface where coating of the poison was visible with a lens. Furthermore, the failure of the dust to accomplish even as good results as the spray seem chargeable to the failure to maintain the excellent coating which was established at each treatment. It seems that the coating of the fruit and foliage obtained by the use of dust was materially more complete than that which was obtained with the liquid spray, but it seems also that the coating thus established remains for a much shorter period than that which was established with the liquid spray. These conclusions were based upon a careful examination of the apple surface with a lens.

Relation of Time of Application to Tree Development

The third problem, namely, the relation between the time that the worms of the second brood attempt to enter the apple and the falling of the blossoms, is one on which data covering a period of years must be obtained. The data obtained from the season of 1919, are set forth on the chart under the brood study, and the data which will be obtained during the present season of 1920 are, of course, not yet available.

Summary

In conclusion it may be said that:

1. The codling moth is at present tremendously abundant in the Glassboro and Maple Shade areas.
2. Many orchardists in these areas are failing to obtain control.
3. Some orchardists in this area are getting good control.
4. In the season of 1919 there were two distinct broods in these areas.

5. A large percentage of the first brood appears to enter the blossom end; this usually has been found to be the case.

6. Present spraying is universally successful in controlling blossom-end injury.

7. *Spraying during the period of entry by side-worms of the first and second broods is absolutely essential to control.*

8. The secret of control of side-worms of the first and second broods appears to lie in keeping the fruit and foliage coated during the periods of entry.

9. *Lead arsenate, all things considered, is the best insecticide for codling moth.*

10. While it is possible to administer a more complete coating of fruit and foliage with dust than with spray, it is not nearly so effective because it does not stick as well as spray and leaves the fruit uncovered for a longer portion of the time.

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Insecticidal Dusts

About eight years ago the entomologist became interested in the question of insecticidal dusts. His interest was attracted to this subject because of the tremendous development in the production of powdered arsenate of lead and extremely finely divided sulfur. Previous to this time the work on insecticidal dusts had largely been confined to the use of lime and paris green used in combination, and tobacco dust used by itself. The failure of the lime and paris green to effect any satisfactory control of serious insects and apple diseases had been decidedly shown by Faurot (1) and others and the use of these materials for the protection of apples and peaches was greatly discouraged thereby.

With the appearance of the powdered lead and finely ground sulfur in marketable quantities, it seemed that the time had arrived for another study of the efficiency of dusts in controlling insects and diseases injurious to tree fruits. Accordingly, in cooperation with F. H. Pough, of the Union Sulfur Company, C. D. Vreeland, of the Vree-

land Chemical Company, Dr. Donald Reddick, of the department of plant pathology at Cornell University, and F. M. Blodgett, of the same institution, a general plan of testing the combination of powdered arsenate of lead and finely ground sulfur on peaches and apples was laid out.

Mr. Pough undertook to get this plan or some substitute therefor adopted by a representative number of the experiment stations in the different fruit-growing sections of the United States east of the Rocky Mountains. So far as the entomologist knows this was the beginning of the 8 years of study of the problem which has been carried out in the country at different stations.

New Jersey Experience

In New Jersey both peach and apple have been under test at various times during the 7-year period, beginning in 1913.

1913

In 1913 the entomologist decided that the only way to give the dust material a really fair test was to make an attempt to maintain the coating throughout the period of fruit development. Realizing at the same time that information concerning its effect when applied on a strictly commercial basis should be obtained, the horticultural department, at the Vineland orchard, applied the mixtures to peach at precisely the same date and exactly the same number of times as the regular self-boiled lime-sulfur schedule called for.

Glassboro Experiments on Peach

Experiments of the first type were located at Glassboro. Seven dust treatments were applied to peach in order to maintain the coating. A sulfur-lead-arsenate-glue paste block was included for the purpose of comparing the same materials applied wet and dry. One block, treated according to the orchardist's own practice and by his own men, was laid out for the purpose of comparing the results of these new materials applied both dry and wet with ordinary orchard practice. The paste block received six treatments, the effort here being to maintain the coating throughout the growing period. The self-boiled lime-sulfur block received only two treatments. The data in so far as they relate to curculio and scab control, the two main parasites interfering at that time with peach production in New Jersey, are set forth in table 1.

It is significant that the sulfur-lead-arsenate applied either dry or wet when the coating was maintained, gave approximately the same curculio control, so cutting down the injury that none of the picked fruit was injured and only about 5 per cent of the total fruit damaged, while about 30 per cent of the total fruit from untreated trees was injured. It is also significant to note in the table that with more than 83 per cent of the picked fruit damaged by scab on the untreated trees, the dust and liquid sulfur-lead-arsenate-treated blocks showed no scab.

TABLE 1

Glassboro Experiments on Peach, 1913

Variety	Kind of treatment and dates	Curculio			Scab		
		Per cent Windfalls	Per cent Picked	Per cent Total	Per cent Windfalls	Per cent Picked	Per cent Total
Carman....	Check	39.7	0.0	29.1	0.0	83.3	22.2
Carman....	Dust, 80-20	19.8	0.0	4.4	0.0	0.0	1.0
Carman....	*Self-boiled Lime-Sulfur*	*37.8*	*0.0*	*13.6*	*0.84*	*14.1*	*9.3*
Carman....	Paste, 11.25 lbs. Sulfur and 1.75 lbs. Lead Arsenate	20.5	......	5.5	0.0	0.0	0.0
Elberta.....	Check	65.3	......	......	0.6	......	......
Elberta.....	Dust, 80-20	14.5	......	......	0.0	......	......
Elberta.....	Self-boiled Lime-Sulfur	45.9	......	......	2.1	......	......
Elberta.....	Paste, 11.25 lbs. Sulfur and 1.75 lbs. Lead Arsenate	23.2	......	......	0.0	......	......

It is further significant to note that the injury done by both curculio and scab was markedly greater on the orchardist's regular treatment than on either the dry or wet lead-arsenate-sulfur blocks.

Vineland Experiments on Peach

At Vineland where the treatments given were exactly those of the regular spraying schedule it is interesting to note that with over 70 per cent of the fruit injured by curculio on the untreated trees the dust showed a little over 43 per cent, the paste a little over 35 per cent and the self-boiled nearly 37 per cent. It is interesting also to note

that with the picked fruit from the untreated trees showing about 90.5 per cent injured by scab, the dust showed about 17 per cent injured, the paste 2.7 per cent and the self-boiled 6.4 per cent (table 2). It is particularly significant to note that the dust on the picked fruit did not give as satisfactory results as did either the paste or the self-boiled. This is doubtless to be explained by the fact that there were periods during the growing season in which the fruit on the dust blocks was unprotected, while on the self-boiled and the paste blocks the coating was present and seemed to have greater sticking power.

TABLE 2

Vineland Experiments on Peach, 1913

Variety	Kind of treatment and dates	Curculio			Scab		
		Per cent Windfalls	Per cent Picked	Per cent Total	Per cent Windfalls	Per cent Picked	Per cent Total
Elberta.....	Check	73.	68.1	70.3	2.0	90.5	51.9
Elberta.....	Dust, 80-20	31.1	45.3	43.3	2.1	16.9	14.8
Elberta.....	Self-boiled Lime-Sulfur, 8-8-50, and 3 lbs. Arsenate of Lead	7.	33.8	31.6	0.0	6.4	......
Elberta.....	Paste, 11.25 lbs. Sulfur and 1.75 lbs. Lead Arsenate	31.6	38.7	35.3	0.0	2.7	......

In examining the curculio data it is particularly interesting to note that the self-boiled was considerably more efficient than either of the lead-arsenate-sulfur mixtures, indicating that the "messiness" of the self-boiled treatment operated as a deterrent factor to the work of the curculio. It is interesting also to note that while the self-boiled gave better results on the picked fruit in scab control than did the lead-arsenate-sulfur dust, the lead-arsenate-sulfur paste gave even better results than did the self-boiled, indicating that the tie-up of the sulfur with the lime in the self-boiled interfered with its fungicidal effect.

From the 1913 work on peach in New Jersey the following conclusions may be drawn, relative to the efficiency of the lead-arsenate sulfur mixtures for control of curculio and scab:

(1) Regardless of whether lead-arsenate-sulfur is applied as a dust or as a spray, it very materially reduces the amount of damage done by the curculio, being in this respect almost as efficient as the ordinary self-boiled mixture.

(2) Lead-arsenate-sulfur, regardless of whether applied as a dust or as a spray, largely reduces scab damage, giving in that respect approximately the same efficiency as self-boiled.

(3) The slightly greater effectiveness of self-boiled against the curculio is probably due to the repellency of the messy mixture and the effectiveness of the lead-arsenate-sulfur mixtures in control of scab on picked fruit is dependent upon their remaining on the fruit throughout the period of infection.

This somewhat optimistic report on the effectiveness of the lead-arsenate-sulfur mixtures in comparison with the ordinary self-boiled plus lead-arsenate treatments needs qualification, because both at Glassboro and at Vineland the foliage of the peaches treated with the lead-arsenate-sulfur mixtures was very seriously burned and a considerable proportion of it, especially at Glassboro, fell from the trees, causing the fruit never to reach the size of the fruit on the blocks treated with the ordinary self-boiled mixture. At the time the experimenters did not feel sure of the cause of the burning, nor did they think of any way in which it could be eliminated.

Glassboro Experiments on Apple

In the apple treatments where the same plan was carried out there was not enough curculio nor codling moth to give data and no facts relative to apple parasites other than scab could be obtained. The data obtained are set forth in table 3. It is interesting to note that the reduction in scab effected by the lead-arsenate-sulfur dust is small, while that effected by the lead-arsenate-sulfur paste is relatively large. In light of later experience, the entomologist believes, this is to be explained on the ground that the smoothness of the fruit prevented the material from sticking, rendering the effort to maintain the coating a partial failure.

There was no evidence that the injury experienced during this year on peach foliage had a counterpart on apple foliage.

In summarizing the experience of 1913 it may be said that the lead-arsenate-sulfur mixtures, especially those which were applied as a paste, were almost as successful in controlling the curculio on peach, and were equally as effective in controlling scab as was the regular self-boiled plus arsenate-of-lead treatment, but this record of efficiency was sadly marred by the damage which they did to peach foliage. This damage reached such proportions as to render them much less satisfactory substances for peach than the self-boiled. The record of apples is altogether too limited to found satisfactory conclusions, except certain ones relating to the control of apple scab. It was obvious from the work of 1913 that the lead-arsenate-sulfur applied, either dry or wet, was relatively inefficient in the control of apple scab, but there was no evidence whatever of damage to foliage due to their action.

TABLE 3

Glassboro Experiments on Apple, 1913

Variety	Kind of treatment	Curculio			Scab		
		Per cent Windfalls	Per cent Picked	Per cent Total	Per cent Windfalls	Per cent Picked	Per cent Total
Phoenix	Check	......	......	......	28.6	51.8	44.8
Phoenix	Dust, 80-20	......	......	......	33.1	30.8	32.5
Smith Cider	Check	......	......	......	56.3	81.5	68.6
Smith Cider	Dust, 80-20	......	......	......	22.8	56.1	46.4
Smith Cider	Paste, 11.25 lbs. Sulfur and 1.75 lbs. Lead Arsenate	......	......	......	14.9	48.8	36.4
Smokehouse	Dust, 80-20	......	......	......	35.7	49.0	42.1
Smokehouse	Paste, 11.25 lbs. Sulfur and 1.75 lbs. Lead Arsenate	......	......	......	13.1	16.1	15.5

1914

In 1914 the lead-arsenate-sulfur studies were continued at Vineland and at Cranbury.

Vineland Experiments on Peach

At Vineland the lead-arsenate-sulfur dust, self-boiled lime-sulfur and lead, lead arsenate and lime, atomic sulfur and lead arsenate were compared on Greensboro, Waddell, Mountain Rose, Reeves' Favorite and Carman varieties of peaches. The data in so far as they relate to curculio are set forth in table 4.

The paste and dust lead-arsenate-sulfur, the self-boiled lime-sulfur and lead arsenate were the same as those used in 1913. The arsenate of lead and lime, and atomic sulfur plus lead arsenate were used according to common practice. No checks were left, although the arsenate of lead block could be considered a check so far as the scab was concerned. The figures represent the results obtained on total fruit.

It is obvious from an examination of the table that lead-arsenate-sulfur, both as a paste and as a dust, materially cut down the amount of both scab and curculio. On scab the dust gave the best results in

three out of four tests. In the fourth it is almost as good as t
paste. Lead-arsenate-sulfur applied as a paste seemed more efficie
than self-boiled or atomic sulfur.

TABLE 4

Vineland Experiments on Peach, 1914

Variety	Treatment	Scab	Curculi
		per cent	per cent
Greensboro	Dust	0.00	0.70
Greensboro	Paste	0.30	4.15
Greensboro	Self-boiled	3.12	1.90
Greensboro	Atomic Sulfur	15.80	4.14
Greensboro	Arsenate	43.10	6.90
Waddell	Dust	9.10	0.90
Waddell	Paste	17.10	1.40
Waddell	Self-boiled	53.11	1.00
Waddell	Atomic Sulfur	56.60	1.30
Waddell	Arsenate	79.11	0.70
Mountain Rose	Dust	0.40	3.00
Mountain Rose	Paste	5.60	2.80
Mountain Rose	Self-boiled	14.60	2.18
Mountain Rose	Atomic Sulfur	16.12	1.70
Mountain Rose	Arsenate	73.30	0.00
Reeves' Favorite	Dust	8.20	10.20
Reeves' Favorite	Paste	6.15	6.16
Reeves' Favorite	Self-boiled	16.14	12.11
Reeves' Favorite	Atomic Sulfur	27.11	12.12
Reeves' Favorite	Arsenate	56.00	
Carman	Dust	1.60	3.60
Carman	Paste	3.10	1.12
Carman	Self-boiled	12.11	2.20
Carman	Atomic Sulfur	24.16	1.10
Carman	Arsenate	51.70	1.80

In examining the data on curculio we find the lead-arsenate-sulf applied as a dust giving the same results as that applied as a past also the results are the same as those which were obtained by the u of self-boiled. In general the arsenate of lead and lime seems have been in some cases not quite as good as the lead-arsenate-sulf mixtures, and in other cases somewhat better. Here again there evidence of the repellency of self-boiled, although it is not so marke as in the previous year.

Taking the peach experiments as a whole, the entomologist thin it can be said that the lead-arsenate-sulfur mixture, either dry or we gave as good results on both curculio and scab as the ordinary sel boiled schedule.

As in 1913 the lead-arsenate-sulfur mixtures applied either as a paste, or as a dust gave serious injury to the foliage and through that action prevented the fruit from having a normal development. Obviously, until a corrective agent could be found which might be introduced into the sulfur-lead-arsenate mixture and protect the foliage from injury, these mixtures could not compare in efficiency with the self-boiled.

Cranbury Experiments on Apple

At Cranbury blocks were compared which were treated with the lead-arsenate-sulfur dusts of 1913, commercial lime-sulfur (1 to 40) plus arsenate of lead and pyrox, and also untreated blocks. The regular schedule advised at that time for apple was followed, making in all a total of 5 treatments during the fruit developing season. The data were taken from picked fruit. Table 5 sets forth the results obtained.

TABLE 5

Cranbury Experiments on Apple, 1914

Kind of treatment	Codling Moth			Scab		
	Per cent Windfalls	Per cent Picked	Per cent Total	Per cent Windfalls	Per cent Picked	Per cent Total
Check	0.95	......	4.70	......	......	33.0
Pyrox	0.15	......	0.31	......	......	1.4
Lime-sulfur	0.90	......	2.70	......	......	16.8
Dust 80-20	4.70	......	4.10	......	......	14.1

It is significant to note in the table that with 33 per cent of the total fruit scabbed on the untreated block, the lead-arsenate-sulfur *dust showed 14 per cent, or 2 per cent less than the commercial lime-*sulfur and arsenate-of-lead block. It is significant also to note that the pyrox showed less than 1½ per cent of the fruit scabbed. At this juncture it should be said, however, that the resultant fruit on the dust block had much the finest finish of any of the blocks, and that the pyrox showed a considerable amount of russeting. It is significant and interesting to note that the dust block showed more codling

moth than did the check, and that the pyrox showed the least codlin moth of any of the blocks. It is further of interest to note that th dust block showed practically no control of the curculio.

While the amount of codling moth and curculio was altogether to small to give a really satisfactory test, it may safely be said that th dust did not effect even a partial control of either and that pyrox di well on both. In summarizing the results it should be said tha *while the lead-arsenate-sulfur dust gave a considerable reduction o* scab and no appreciable reduction of either codling moth or curculic the fruit on the dust block came to picking time with the finest finis of any. It should also be said that while pyrox showed the best con trol of curculio, codling moth and scab, the fruit was seriously rus seted. The failure of the lead-arsenate-sulfur dust to effect contro of curculio and codling moth is, the entomologist believes, chargeabl to the fact that the smoothness of the apple fruit prevented the coat ing from remaining on the apple for anywhere nearly so long a perio as did the materials applied in liquid form.

1915-1916

During this period no further experimental work on dusting peache or apples was carried out by the New Jersey Station for two reasons

(1) No agent to prevent the burning of peach foliage by the lead arsenate-sulfur mixtures was known.

(2) The *control of codling moth, curculio and scab obtained o* apple seemed not to be nearly so satisfactory as that which could b obtained with the spraying mixtures already in general use.

1917

In this year hydrated lime having been found to act as a satisfactory corrective for the burning which lead-arsenate-sulfur dusts naturally *did to peach foliage, it seemed that the time had arrived for a* furthur test. Accordingly, the horticultural department undertook a test of lead-arsenate-sulfur and hydrated lime mixtures on peaches at Howard F. DeCou's farm, near Haddonfield, comparing them with the ordinary self-boiled treatment and the lead, arsenate, sulfur, lime and glue mixtures. The varieties included were Carman, Frances, Edgemont, Elberta and Krummel's October. An account of this work appeared in the Annual Report of the New Jersey State Horticultural Society for 1917. The data set forth relate entirely to scab, but show *almost but not quite as good results with the sulfur-lime-lead-arsenate* dust as with self-boiled lime-sulfur. Considering the great labor saving of dust applications, it seems fair to say that the dust was commercially the equal of the self-boiled lime-sulfur.

1918

No work on the dusting of apples or peaches was undertaken because it was felt that the lead-arsenate-sulfur-lime dust had proven itself as a satisfactory substitute on peaches for self-boiled lime-sulfur and arsenate of lead, and the results of the lead-arsenate-sulfur dust had been unsatisfactory in the control of codling moth and curculio on apple.

1919

In 1919 an opportunity to compare lead-arsenate-sulfur dust with commercial lime-sulfur and lead arsenate for the control of curculio and codling moth arose, and an experiment was staged near Moorestown. Three blocks were included. All blocks received the delayed dormant spray with winter-strength lime-sulfur and "black leaf 40."

TABLE 6

Results of Spraying—Dusting Experiments at Moorestown

Block No.	Lbs. Total Fruit	Per cent Absolutely Clean	Damaged							
			by Curculio	by Codling Moth			by Aphis	by Scab	by Bitter Rot	by Spray
				Total	First Brood	Second Brood				
1	2783	28.5	20.0	66.0	15.0	50.0	Neg.	22.0	Neg.	Neg.
2	2820	21.3	9.5	30.3	7.4	22.9	Neg.	61.4	Neg.	Neg.
3	3134	32.3	6.7	30.6	7.9	22.7	Neg.	51.4	Neg.	Neg.

The first block was given the pink-bud spray, the blossom-fall spray and treatments 10 days after blossom-fall between June 20 and 30 and a second-brood codling-moth treatment about the third week in July, with an 85-15 sulfur-lead-arsenate dust. Block 2 received precisely the same number of treatments with commercial lime-sulfur (1 to 40) to which powdered arsenate of lead was added at the rate of 3 pounds to 100 gallons. Block 3 received the liquid treatments until June 20-30. The treatment applied between June 20 and 30 and repeated about the third week in July was made with dust. All these treatments were applied by the orchard owner with his own machines and

with his own men. The usual method which he employed of spraying and dusting with the wind only was used here. No count was made of the dropped fruit, the data being taken on the picked fruit only. Table 6 sets forth the results.

It should be said at the outset that the control of codling moth, curculio and scab even under the best treatments was unsatisfactory and that this is chargeable to the failure to obtain and maintain complete coating. The codling moth in this orchard was extremely abundant, having infested not only 100 per cent of the unsprayed apples, but showed as high as 3 worms in a single apple.

It is significant to note in the table the comparative failure of the dust mixtures to control curculio. In blocks 2 and 3 the period of curculio damage was covered by the liquid treatments and the control was easily twice as good as that obtained with the dust application. Similar results were found in the control of the codling moth of both the first and the second brood. The control was twice as good where the liquid applications were present as where dust alone was used. On the other hand, the control obtained on scab with the dust was materially better and doubtless that phenomenon is to be charged to the fact that the dusts gave a more complete coating at the time of application than did the sprays.

In summarizing the results of testing the dust lead-arsenate-sulfur and commercial lime-sulfur and arsenate of lead in the year 1919, it may be said that so far as codling moth and curculio are concerned the results of 1919 confirm those obtained in 1914, and distinctly indicate that in the lead-arsenate-sulfur dust mixtures, in their present form, we have an agent not to be compared in efficiency with the present commonly used sprays. The results in control of scab differ materially from those obtained in 1913 and 1914, but the importance of a coating at the critical time for the control of scab may explain this seeming contradiction. This is on the assumption that the dust materials were applied in 1919 at the critical stage.

The entomologist kept these blocks under rather close observation throughout the season and noted the fact that in periods between treatments the fruit and foliage on the sprayed trees showed much evidence of spray material at times when the lead-arsenate-sulfur dust material had entirely disappeared from the fruit and foliage. He noted also that curculio and codling-moth injury seemed to take place in the periods when the fruit was not coated. Such periods, in the case of the lead-arsenate-sulfur dust being materially longer, the amount of damage done by curculio and by codling moth was correspondingly greater. This led him directly to the conclusion that the trouble with the lead-arsenate-sulfur dusts is primarily due to their failure to stick to fruit and foliage as do materials applied in a liquid form. This finally led him to plan for 1919-20 a series of studies intended to discover means of making the dust materials stick to fruit and foliage.

1920

During the fall and winter the entomologist, whose interest had been attracted to this subject by the work against the walnut aphid, reinforced by the desire of New Jersey growers of both fruit and vegetables, particularly the latter, for such a compound, planned a series of laboratory studies followed by field tests of such materials as are already on the market and such other compounds as he could manufacture.

Orchard Tests

Before the execution of this plan could begin, a meeting of the entomologists of New York, Connecticut, Pennsylvania and New Jersey was held at New York City. At this meeting, which was called by Prof. P. J. Parrott and C. R. Crosby, it soon developed that the majority desired field tests of apple dust mixtures already in the market impregnated with various strengths of nicotine as protection against plant lice, red bugs and leaf hoppers.

The agreement finally reached covered the following points:

(1) Basic dust should consist of 90 parts of sulfur (200-mesh) and 10 parts of powdered lead.

(2) This basic mixture should be divided into three parts, one of which should be impregnated with 0.5 per cent nicotine, another with 1 per cent and still another with 3 per cent.

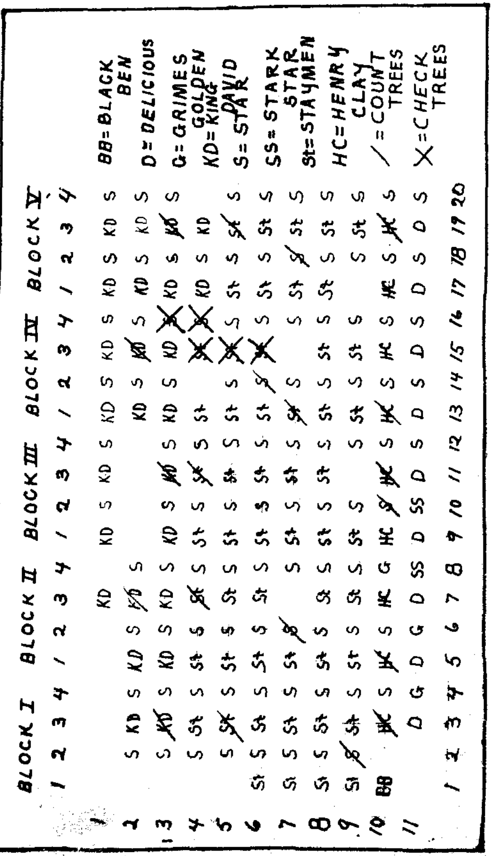
(3) In so far as practicable five blocks of not less than 20 trees each should be included in the experiment and treated as follows:

(a) All blocks to receive the delayed dormant, pre-pink and blossom-fall applications, and all further treatments to vary as the needs of fruit protection indicates.

(b) Block 1 to receive the 90-10 impregnated with 0.5 per cent nicotine.
Block 2 to receive the 90-10 impregnated with 1 per cent nicotine.
Block 3 to receive the 90-10 impregnated with 3 per cent nicotine.
Block 4 to receive regular liquid treatments.
Block 5 to receive no treatment.

(4) Data are to be taken on all fruit borne by 4 to 6 trees in the center of each of the treated blocks and the check. Scab is to be scored according to the pathologist's standards as set forth in the proceedings of the recent meeting in Washington. In so far as possible worms, side-worms and shallow worms are to be determined. Spring and fall punctures of curculio are to be recorded. Actual worminess of dropped fruit is to be determined and scars are to be used as a basis of determining injury to picked fruit.

In accordance with the above plan the entomologist enlisted the cooperation of the acting horticulturist, Prof. A. J. Farley, and together they selected the block in J. Howard Lippincott's orchard near Moorestown. Figure 2 shows the layout and arrangement of the blocks. The trees ranged from 12 to 20 feet in height and branches were very thickly set on them.


BLOCK I
BLOCK II
BLOCK III
BLOCK IV
BLOCK V
BB = BLACK BEN
D = DELICIOUS
G = GRIMES GOLDEN
KD = KING DAVID
S = STAR
SS = STARK STAR
St = STAYMEN
HC = HENRY CLAY
/ = COUNT TREES
X = CHECK TREES

On April 15 blocks 1, 2, 3 and 5 were treated (schedule spray 1) as follows:

Block 1—90-10 dust; nicotine 0.5 per cent; 180 lbs.
Block 2—90-10 dust; nicotine 1 per cent; 220 lbs.
Block 3 (rows 1 and 2)—90-10 dust; 3 per cent nicotine; 100 lbs.
Block 4—Owner's treatment.
Block 5 (rows 1 and 3)—Liquid lime-sulfur (1 gal.), water (9 gal.), 40 per cent nicotine at the rate of 1 to 500.

On April 23 and 24 J. W. Thomson made counts of the aphis all of which belonged to *Aphis avenæ* with the following results:

Block 1—200 fruit buds; 27 lice, or 0.13 per bud.
Block 2—200 fruit buds; 17 lice, or 0.085 per bud.
Block 3—No count.
Block 4—200 fruit buds; 76 lice, or 0.38 per bud.
Block 5—200 fruit buds; 10 lice, or 0.05 per bud.

The failure to count block 3 came about through a misunderstanding. In selecting buds from block 5, rows 3 and 4 were included.

On April 26 the blocks were given the pink-bud treatment (schedule spray 2) as follows:

Block 1—Dust impregnated with nicotine. 0.5 per cent; 141 lbs.
Block 2—Dust impregnated with nicotine, 1 per cent; 156 lbs.
Block 3 (rows 1 and 2)—Dust impregnated with nicotine, 3 per cent; 78 lbs.
Block 4—Owner's treatment.
Block 5 (rows 1 and 3)—Liquid lime-sulfur (1 gal. to 40 gal. of water), lead-arsenate powder (3 lbs. to 100 gal.).
Block 5 (rows 2 and 4)—Same as rows 1 and 3, but with the addition of nicotine (40 per cent) at the rate of 1 to 500.

On April 29 the following counts were made:

Block 1—200 fruit buds, 39 lice, or 0.19 per bud.
Block 2—200 fruit buds, 10 lice, or 0.05 per bud.
Block 3 (rows 1 and 2)—200 fruit buds, 1 louse, or 0.005 per bud.
Block 4 (rows 3 and 4)—200 fruit buds, 9 lice, or 0.045 per bud.
Block 5 (rows 1 and 3)—400 fruit buds, 0 lice.
Block 5 (rows 2 and 4)—400 fruit buds, 0 lice.

All blocks received a winter-strength treatment of commercial liquid lime-sulfur. Block 4 had received nothing additional when counts of April 23 and 24 were made, and the results therefore indicate the degree of infestation in all blocks when the experiment began. In dealing with the rosy aphis, the infestation indicated on block 4—0.38 lice per bud, would constitute with favorable weather a dangerous infestation. Of course, the oat aphis rarely if ever is a dangerous form even if excessively abundant and it is more easily killed than either the green or the rosy.

Nevertheless, the results give some indication of what might be expected to occur when dealing with the other and dangerous species. The data show that with 1 per cent applied at the green-bud stage, the infestation was reduced from 0.38 to 0.05 lice per fruit bud, and it is reasonable to anticipate a greater reduction in the 3 per cent block. The 0.5 per cent treatment was shown to be ineffective. The results with liquid were good, as shown in examinations made on April 23 and 24 just after the delayed dormant spray, for assuming that the 10 lice found all came from rows 3 and 4, which were not sprayed at the green-bud stage because of too forward development, we find an infestation of only 0.1 per fruit bud as compared with 0.38 per fruit bud in block 4.

When we examine the counts made on April 29 after the pink-bud treatment had been applied, we see further significant facts. The block 4 infestation has been cut by a pink-bud spray consisting of 1 gallon of commercial liquid lime-sulfur concentrate to 40 gallons of water plus 3 pounds of powdered lead arsenate to 100 gallons plus "black leaf-40" at the rate of 1 to 500 applied by the owner, from 0.38 to 0.045 lice per fruit bud. Rows 3 and 4 of block 5 show a reduction of aphis from approximately 0.1 to 0.0 per bud by the application of the pink-bud spray made the same as that which was applied to block 4.

Taking the plant lice data as a whole, it may be said that in dealing with oat aphis on apple 0.5 per cent nicotine seems ineffective, 1 per cent nicotine reduces to the point of control, 3 per cent is stronger than necessary, spraying with winter-strength lime-sulfur and nicotine is best of all, and a real specific and very effective reduction can be obtained at the pink-bud stage by thorough applications of liquid lime-sulfur (1 to 40) plus nicotine (1 to 500). It should also be said that reduction obtained by dust at the green-bud stage is not equal to that obtained by the liquid treatment at the same time, the dust with 0.5 per cent nicotine giving 0.13 and with 1 per cent 0.085, as compared with 0.0 for liquid. Nevertheless, for oat aphis the 1 per cent dust does reduce to a point of control.

On May 15 the blocks were given the blossom-fall treatment as follows:

Block 1—Dust (90-10), 5 per cent nicotine; 110 lbs.
Block 2—Dust (90-10), 1 per cent nicotine; 125 lbs.
Block 3—Dust (90-10), 2 per cent nicotine; 125 lbs.
Block 4—Owner's treatment.
Block 5—Liquid lime-sulfur (1 to 40), lead-arsenate (1.5 lbs. to 50 gal.); 210 gal.

On May 22 the blocks were given the 1-week-after-blossom-fall treatment as follows:

Block 1—Dust (85-15); 100 lbs.
Block 2—Dust (85-15); 120 lbs.
Block 3—Dust (85-15); 120 lbs.
Block 4—Owner's treatment.
Block 5—Liquid lime-sulfur (1 to 40), lead-arsenate (1.5 lbs. to 50 gal.); 200 gal.

On June 4 the blocks were given the 17-days-after-blossom-fall treatments as follows:

Block 1—Dust (90-10), 0.5 per cent nicotine; 100 lbs.
Block 2—Dust (90-10), 1 per cent nicotine; 120 lbs.
Block 3 (rows 1 and 2)—Dust (90-10), 3 per cent nicotine; 50 lbs.
Block 3 (rows 3 and 4)—Dust (85-15), 60 lbs.
Block 4—Owner's treatment.
Block 5—Liquid atomic sulfur (27 lbs. to 200 gal.) plus powdered lead-arsenate (6 lbs. to 200 gal.); 40 per cent nicotine (1 to 500); 200 gal.

On June 8 Dr. Peterson made a study of leaf-hopper conditions in these blocks with the following results:

Block 1 (row 2)—Examined 1000 leaves; found 15 leaf hoppers.
Block 2 (row 2)—Examined 1000 leaves; found 7 leaf hoppers.
Block 3 (row 1)—Examined 1000 leaves; found 7 leaf hoppers.
Block 3 (row 3)—Examined 1000 leaves; found 32 leaf hoppers.
Block 4 (row 2)—Examined 1000 leaves; found 76 leaf hoppers.
Block 5 (row 2)—Examined 1000 leaves; found 4 leaf hoppers.
Checks—Examined 1000 leaves; found 108 leaf hoppers.

On June 4, in an orchard at Maple Shade when immature leaf hoppers were very abundant indeed, averaging about 3 per leaf, the entomologist in company with Prof. A. J. Farley, treated 4 rows of trees averaging about 22 feet high. Treatments were made both from underneath and from the outside of the tree. These rows were a part of the demonstration block in charge of A. F. Mason, of the extension division. On June 8 Dr. Peterson made examinations in this orchard. He counted the leaf hoppers on 100 leaves picked from each of 30 trees, making a determination of the leaf hoppers on 3,000 leaves per row. These rows were thus examined—row 3 being treated by Mr. Mason both from underneath and the outside, row 8 being treated as above described by Professor Farley and the entomologist, and row 13 by the orchard owner's organization. The results follow:

Original infestation (estimated) per 3000 leaves.........	9000
Row 3—Hoppers found per 1000 leaves................	90
Row 8—Hoppers found per 1000 leaves................	25
Row 13—Hoppers found per 1000 leaves................	299

Thus it appears that thorough spraying with lime-sulfur (1 to 40) plus 40 per cent nicotine (1 to 500) gives greater reduction of leaf

hopper than any other treatment tried, that underneath spraying is an important factor, but that nicotine-impregnated dust does pretty effective work, 0.5 per cent reducing from more than 100 leaf hoppers on 1,000 leaves to 15 for the same number, 1 per cent from the same number to 7, and 3 per cent the same reduction as 1 per cent. As a matter of fact, the entomologist believes that the 1 per cent treatment gives sufficient reduction to effect a control of the insect.

On June 19 the blocks were given the first side-worm treatment (schedule spray 6) as follows:

Block 1—Dust (85-15), 100 lbs.
Block 2—Dust (85-15), 120 lbs.
Block 3—Dust (85-15), 120 lbs.
Block 4—Owner's treatment.
Block 5—Liquid atomic sulfur (27 lbs. to 200 gal.) plus powdered lead-arsenate (6 lbs. to 200 gal.); 200 gal.

The complete report of the results on the above-described orchard tests will not be available until the close of the present summer, 1920; the laboratory and field studies of various dust combinations had only been begun at the close of the present fiscal year.

Experience in Other Parts of the United States

Peach

In 1918 W. W. Chase, assistant entomologist of the Georgia State Board of Entomology, published Circular 21 on Experimental Dusting and Spraying of Peaches. It seems that Mr. Chase had to deal primarily with the curculio, scab and brown rot. Examination of his data shows that the lead-arsenate-sulfur mixtures exert a control of brown rot, scab and curculio slightly less efficient than the spraying mixtures. Further examination of his data serves to show that the inclusion of a large amount of hydrated lime appears to interfere with the effectiveness of the material in the control of these parasites, except in the case of scab where the inclusion of a large amount of lime seems to render the mixture less effective.

In January, 1920, Dr. W. H. Wetzel, plant pathologist of Cornell University, delivered before the New York Horticultural Society an address on the status of experimental dusting for control of peach insects and diseases. He summarizes the data from Georgia, West Virginia and Virginia.

He brings out the idea that these data show an equal or better control of scab with dusting mixtures than with spraying. He brings out also the fact that the same condition holds for brown rot and curculio. It may be said that the New Jersey experiences covering a number of years corroborate these findings. In view of the lead-

arsenate-sulfur-lime dusts from all these series of experiments in New Jersey and elsewhere giving about the same results in control of scab, brown rot and plum curculio, the entomologist is inclined to believe that these dust materials have been thereby established as a satisfactory substitute for self-boiled lime-sulfur plus arsenate of lead for the control of the diseases and insects attacking the peach during the growing season.

Apple

In January, 1914, F. M. Blodgett, plant pathologist at Cornell University, presented in Bulletin 340 of the New York (Cornell) Agricultural Experiment Station an account of a series of experiments which were located in the Kinne Orchard, the Catchpole Orchard and the Lawson Orchard. Mr. Blodgett compared the use of sulfur and arsenate of lead in dust form, sulfur-lead-arsenate in liquid form and commercial lime-sulfur (1 to 40) plus arsenate of lead (1 pound to 50 gal.) and no treatment whatever. This experiment was confined entirely to apple.

In dealing with the curculio in the Kinne Orchard the non-treated blocks showed 73.2 per cent while the treated blocks showed 4.2 per cent, 5.2 per cent and 6.0 per cent for lead-arsenate-sulfur paste, commercial lime-sulfur and lead arsenate and lead-arsenate-sulfur dust, respectively.

The same insect at the Catchpole Orchard and the Lawson Orchard with the exception of the Northern Spy was so small on the check as to render the results unreliable. On the Northern Spy, however, at the Lawson Orchard 32.1 per cent injury by the curculio was reduced by dust to 14.7 per cent, by paste to 4.8 per cent, by commercial lime-sulfur and arsenate of lead to 4.8 per cent. It would seem from the data just cited that the dust was almost as efficient as the commercial lime-sulfur in the Kinne Orchard, but in the Lawson Orchard it was only one-half as efficient.

In dealing with the codling moth at the Kinne Orchard Mr. Blodgett's tables show that the reduction obtained with the dust was equally as good as that obtained by the commercial lime-sulfur and lead arsenate. The same condition obtained at the Catchpole Orchard. Mr. Blodgett's tables show the dust giving better control of the codling moth at the Lawson Orchard on the varieties Tompkins and Northern Spy than was obtained by the commercial lime-sulfur and arsenate of lead, but it must be said that the control obtained at the Lawson Orchard with any of the substances could hardly be considered satisfactory.

In dealing with the scab Mr. Blodgett's tables show at the Kinne Orchard the commercial lime-sulfur and arsenate of lead to be more than twice as efficient as the lead-arsenate and sulfur dust. At the

Catchpole Orchard the commercial lime-sulfur and arsenate of lead was again shown to be markedly more efficient than dust. At the Lawson Orchard the dust was shown in two cases to be markedly less efficient than commercial lime-sulfur and arsenate of lead and in the third case to be somewhat more efficient than commercial lime-sulfur and lead arsenate.

In summarizing these results it may be said:

(1) That the lead-arsenate-sulfur dusts were in one case markedly less efficient than was the commercial lime-sulfur plus lead-arsenate, and in another almost as efficient, in the control of the curculio.

(2) That the control of the codling moth obtained with lead-arsenate and sulfur dust is as good as that which was secured with the commercial lime-sulfur plus lead arsenate.

(3) That the commercial lime-sulfur plus arsenate of lead was in general markedly more efficient in control of the scab than lead-arsenate-sulfur dust.

In January, 1915, Donald Reddick and C. R. Crosby (2) published results of their tests made in the year 1914. These tests cover a series of three different orchards. No data on curculio seem to have been obtained during that year. The data on codling moth must be considered unreliable, because in no case did the check show much over 5 per cent. The data on apple scab, on the other hand, were extensive and indicate in general that commercial liquid lime-sulfur plus arsenate of lead was materially more efficient.

In January, 1916, the two investigators mentioned in the preceding paragraph presented a report of their studies made during 1915. These studies covered five different orchards.

The data obtained on curculio were limited to picked fruit, the check in one instance showing as high as 29.27 per cent of the fruit marked. In general, the results indicate that the control obtained with lead-arsenate-sulfur dust was as good as that obtained with commercial lime-sulfur plus arsenate of lead. In some cases the commercial lime-sulfur plus arsenate of lead proved better, and in other places it proved not so satisfactory. The results obtained on the check showed 10 per cent or more of the picked fruit injured, and were seemingly unsatisfactory because at best the reduction was hardly more than one-half.

The data on the codling moth show some heavy infestations, reaching as high as 46 per cent, of the check and some remarkable reductions. The facts were obtained from picked fruit only. Taking the record in general the writer thinks it may be said that the control exerted by the lead-arsenate-sulfur dust was as good as that obtained with commercial lime-sulfur and arsenate of lead.

The apple scab data in most cases were not very reliable, because the check blocks show a low percentage of infestation. The data here were obtained exclusively from picked fruit. With the exception of one instance the commercial lime-sulfur plus arsenate of lead exerted a better control of scab than did lead-arsenate-sulfur dust.

In January, 1920, Dr. H. H. Whetzel (3), in an address before the New York State Horticultural Society, made an attempt to summarize the work done on dusts in different parts of the United States. He presents data from New York involving 4 years of experimental work; data from Michigan involving 5 years of experimental work; data *from Nova Scotia involving 3 years of experimental work, and data* from Illinois involving 4 years of experimental work, also letters from Ontario, Virginia, West Virginia and Minnesota and results of a questionnaire sent out to 225 growers from which a 50 per cent reply was received.

Dr. Whetzel shows in his summaries that in the work done in New York, Michigan and Nova Scotia, control of scab and worms (codling moth) is practically the same with arsenate of lead-sulfur dust as with commercial lime-sulfur plus arsenate of lead. In his summary of the various letters received we find both favorable and unfavorable comment. From the questionnaire which was sent out to New York growers who were owners of dusters, and from which he received more than 112 replies, 49, or 43 per cent of the total, answered that dusting controlled the scab as well as or better than spray, and 51, or 45 per cent, answered that dusting controlled the codling moth as well as or better than the spray.

This presentation by Dr. Whetzel makes out an apparently good case in favor of the efficiency of the present dusting methods for the control of insects and diseases seriously injurious to the apple crop. Let us analyse these results.

New York has only one full brood of codling moth with a very partial second, consequently the treating done in the early portion of the season covering a relatively short period of time is supremely important.

In Michigan, while there are two broods of codling moth, the data quoted by Dr. Whetzel show a very light infestation in all years in which tests were carried on, consequently the facts obtained therefrom are not to be relied upon to a great extent. In the experiment cited from Nova Scotia, where the insect is single-brooded, the amount of infestation is obviously very small. The objection which has just been raised in the preceding sentence applied to data from Michigan, applies here with much greater force.

In Illinois the codling moth is 2-brooded, but even here for the first 2 years the worminess was less than 2 per cent, and in the last 2 years when worminess reached from 76 to nearly 84 per cent the dust in one case (1917) showed materially better than the spray, and in the other case (1918) the dust was materially less effective than the spray.

Taking into consideration the facts that the insect was comparatively rare in the majority of instances cited,that it was single-brooded in the New York instance where it was abundant, and that the data were contradictory in the 2-brooded area where it was abundant, the entomologist believes it may safely be said that the conclusions set

forth by Dr. Whetzel as to the efficiency of dust in the control of the codling moth will not necessarily hold where its abundance is great and where it has two or more broods.

The optimistic results of codling-moth control as outlined by Dr. Whetzel certainly do not seem to apply to the main orcharding sections of New Jersey.

Dr. Whetzel's summaries do not include the plum curculio and the data which the entomologist has examined from New York State on this insect, where the said insect is abundant, would not lead one to conclude that the control exerted by lead-arsenate-sulfur dust is as efficient for this insect as the spray. Certainly the New Jersey results do not give a person reason to conclude that the lead-arsenate-sulfur dust can compare in the efficiency in control of this insect with the commercial lime-sulfur plus arsenate of lead.

There seems to be a great deal of contradictory evidence on the efficiency of lead-arsenate-snlfur dust against scab, which is probably due to the relation of time of application to the period of heavy infection. In general, orchard experience in New Jersey has shown that the apple scab has not been nearly as efficiently controlled with lead-arsenate-sulfur dust as with commercial lime-sulfur plus arsenate of lead, yet there are instances in which the opposite has been proved. Even in Dr. Whetzel's summary there are instances in which the scab control by both the spray and the dust seems to have been very incomplete. This can mean only that the relation between the time of treatment and the period of infestation has not been properly met.

What is the factor that causes both the spray and dust treatments to fail in obtaining a satisfactory and reasonable control of the codling moth, curculio and the apple scab? It seems obviously reasonable that this factor is the absence of the protective mixture on fruit and to a considerable extent on foliage when the infestation is taking place. If this reasoning is correct it is obvious that the problem must be met by modified dust treatments which will insure the presence of the mixture at the time the infestations are taking place. It is extremely difficult, even with the best orchardmen and experimenters the entomologist has ever seen, to obtain anything like a complete coating of the foliage and fruit of apple with the liquid spray, consequently the liquid spray has a limit beyond which it cannot go. It has been the entomologist's observation that the relatively inexperienced man can obtain a more complete coating of the fruit and foliage of the apple with a good duster than the most experienced man can effect with a good spray apparatus. It has fnrther been the observation of the entomologist that a relatively thorough and complete coating administered with a dust machine which would disappear in the course of a week has been far less efficient than the relatively incomplete coating which was given with the spray machine.

If these observations and reasoning are correct, the proper way to solve the problem is to produce a dust which will stick to the fruit and foliage of the apple at least equally as well as the spray, or as much better as possible.

Despite the much greater speed with which the dusting materials can be applied the relative inefficiency of these materials because of their failure to stick to the fruit and foliage is such that, in the entomologist's judgment, they cannot in their present stage of development be safely recommended as a substitute for liquid spray in areas where the codling moth, curculio and scab are exceedingly abundant.

Summary and Conclusions

In view of the facts that have been set forth in the foregoing discussion of dusting the entomologist believes that the following conclusions are justified:

(1) The lead-arsenate-sulfur-lime dust is a satisfactory substitute for self-boiled lime-sulfur for the control of curculio, scab and brown rot of the peach.

(2) The lead-arsenate-sulfur dust, in view of its relative failure to effect control of codling moth and plum curculio, cannot be considered a satisfactory substitute for present well-known sprays in the control of these insects on apple.

(3) In view of the great need of a more complete coating of fruit and foliage that can be realized by the use of the dust, a thorough investigation which will result in forms of dust that will stick to fruit and foliage of apple quite as well as or better than liquid mixtures, should be undertaken and prosecuted with utmost vigor.

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A Preliminary Report on the Use of New Mechanical Protectors

For the Control of the Peach Tree Borer, Sanninoidea Exitiosa Say

ALVAH PETERSON

For a number of years investigators have tried to develop a mechanical protector which will prevent newly-hatched larvæ of *Sanninoidea exitiosa* Say from entering the trunk and roots of peach

trees. A few years ago a tarred paper collar, called Scott's tree protector (pl. 2, fig. 8c), gave considerable promise of success. This paper collar when properly sealed is supposed to act as a barrier and cause the newly-hatched larvæ to lose their way, but as a matter of fact a large number of the young larvæ are able to reach the trees in spite of this barrier. The author has observed the behavior of the larvæ and noted the fact that they crawl out to the margin of the protector and then onto the under-side and back to the tree. The point of entrance of many of the larvæ in trees bearing protectors is just below the point where the collars are sealed to the tree. So far as observed larvæ do not penetrate the seal (paraffine or tar-like substances), consequently the above position of the larvæ can be explained only by the fact that the larvæ came to the tree by crawling over the underside of the collar. A number of investigators have conducted careful experiments with Scott's tree protectors or with similar protectors and their results show some or no reduction in the infestation. The anthor has used these protectors for 3 years and the average reduction has been 40 to 60 per cent. This is not sufficient to warrant their use in a commercial orchard.

The above experiments show that a simple collar does not prevent many larvæ from entering, consequently some other impassable barrier must be employed. During the past season Dr. T. J. Headlee and the anthor conceived the idea of making a protector that possessed a trongh which the larvæ would have to cross before they reached the tree. In this trough various repellents (chemical substances) might be placed. Two types of protectors possessing troughs were given a preliminary trial on a number of 6-year-old peach trees at the College Farm. The diagrammatic drawings and the photographs show the construction of the two types.

Type A protectors (pl. 1, fig. 3, and pl. 2, A) were made of two-ply roofing paper with the trough outside of the cone. These were made from a pattern similar to figure 5 in plate 1. The cut paper

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PLATE 1

FIG. 1. DIAGRAMMATIC DRAWING OF TYPE B PROTECTOR MADE OF ROOFING PAPER WITH THE TROUGH INSIDE THE CONE. THE SHADED AREA INDICATES THE DISTRIBUTION OF THE PARAFFINE ON THE OUTER SURFACE OF THE CONE. a. PAPER CLIP.

FIG. 2. DIAGRAMMATIC DRAWING OF TYPE B PROTECTOR MADE OF TIN WITH THE TROUGH INSIDE OF THE CONE. THE SHADED AREA INDICATES THE DISTRIBUTION OF THE PARAFFINE ON THE OUTER SURFACE OF THE CONE. b, CORK; c, HOLE; d AND e, METAL CLAMP.

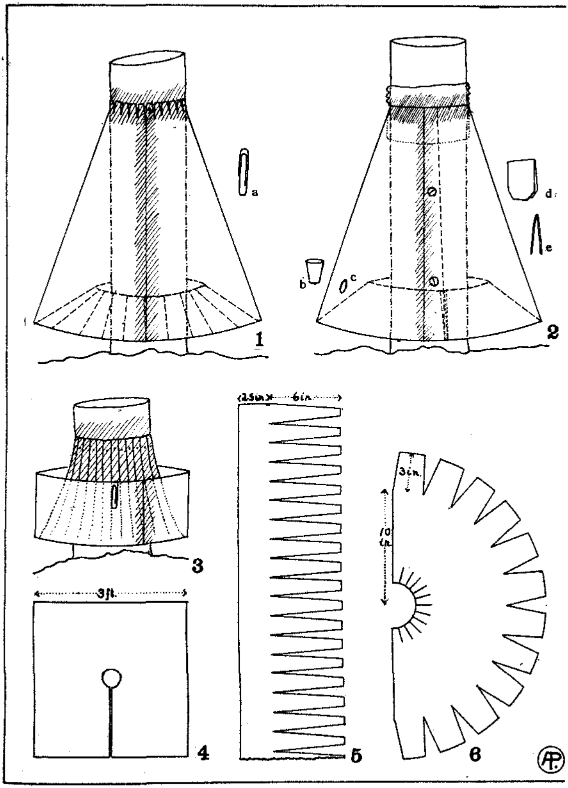
FIG. 3. DIAGRAMMATIC DRAWING OF TYPE A PROTECTOR MADE OF ROOFING PAPER WITH THE TROUGH OUTSIDE THE CONE. THE SHADED AREA INDICATES THE DISTRIBUTION OF THE PARAFFINE OVER THE VISIBLE OUTER SURFACE.

FIG. 4. PATTERN FOR CLOTH PROTECTORS USED IN EXPERIMENTS 7 TO 9.

FIG. 5. PATTERN FOR TYPE A PROTECTORS MADE OF ROOFING PAPER (FIG. 3).

FIG. 6. PATTERN FOR TYPE B PROTECTOR MADE OF ROOFING PAPER (FIG. 1).

PLATE 1



was bent into the desired shape and then fastened about the trunk of the tree a few inches above ground. The overlapping edges of the trough were held in position by strong paper clips and the protector was fastened to the tree by a string or tacks. All the cracks, particularly those in the cone portion of the protector, were completely closed with melted paraffine ("Parowax"). This made the protector water-tight. A small hole was punched in the trough near the base of the outer perpendicular portion in order that rain-water might drain off. This protector was used without any substance in the trough (experiments 13 and 14) and with sand (experiments 10 to 12).

Type B protectors (pl. 1, fig. 1, 2, and pl. 2, Bp. and Bt.) were made of two-ply roofing paper and some of roofing tin. The trough in these protectors was located inside or underneath the cone and thus it was protected from rain, wind and dirt. The protectors, made of roofing paper were cut according to the pattern shown in figure 6 of plate 1 and then bent into the desired position (pl. 1, fig. 1). The outer margin of the cut piece is bent inward and upward and made into a cone. The overlapping cut edges of the trough were held in position by means of paper clips and paraffine. The protectors were placed about upright trees and fastened by a string or two tacks. All cracks in the protectors and open places between the protector and the tree were sealed with melted paraffine. When these protectors were in place the lower margin of the cone was 2 to 4 inches from the soil and the inner margin of the trough was one or more inches away from the trunk of the trees.

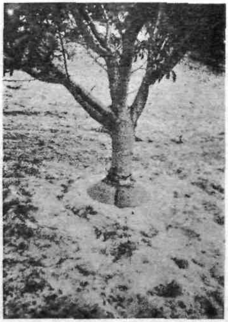
The type B tin protectors were made for us by a tinner. The trough of the protector was made water-tight by soldering the lower margin of the trough and by blocking the two ends of the trough with pieces of tin. The two blocked ends came together when placed about the tree and a strong metal clamp (pl. 1, fig. 2, d and e) was placed over the two upper edges of the blocked ends. This clamp formed a bridge over which the larvæ might crawl if they found it. To obviate this possibility the clamp was thoroughly coated with a thick layer of fresh sticky material, "Tanglefoot." The overlapping edges of the tin protectors were held in position by small iron bolts. Between the upper margin of the protector and the tree, a heavy band of cloth or paper was placed in order that a tight fit might be made without injuring the tree. A small hole was made in the tin protector three inches from the lower margin of the cone (pl. 1, fig. 2, c and b). Through this hole the liquid was poured into the trough and then the hole was plugged with a cork. All cracks or openings on the protectors were sealed with paraffine after the protectors were placed on the trees.

Sand, calcium chloride, and sodium chloride were placed in the troughs of type B protectors made of roofing paper. Water, kerosene and a miscible oil ("Scalecide," 1-15) were poured into the troughs

A

B-p

B-t



Sc

A. Photograph of Type A Protector, Same as Figure 3 in Plate 1.
B-p. Photograph of Type B Protector Made of Roofing Paper, Same as Figure 1 in Plate 1.
B-t. Photograph of Type B Protector Made of Tin, Same as Figure 2 in Plate 1.
Sc. Photograph of Scott's Tree Protector Made of Roofing Paper.

of the protectors made of tin. A few paper and tin protectors had no substance placed in their troughs. In experiment 25 the water placed in the trough evaporated or leaked out, at least the trough was empty when the eggs were hatching, consequently we may consider this as an empty protector.

The protectors were applied to upright 6-year-old trees on August 21, 1919. Before they were placed on the tree two thorough examinations were made for borers and only a few were found. These trees had never been seriously infested, so far as known. The following experiments are few in number, consequently to be sure that each protector was given a satisfactory test a total of 200 eggs in separate lots of 25 to 75 were placed on each tree at three intervals after August 21. The check trees each received 50 eggs apiece and these eggs were deposited by different females. This gave us a check on the percentage of hatch of the eggs of each female. In all cases the hatch was 90 per cent or better when they were not parasitized. The trees (experiments 7 to 9) with canvas about them received 150 eggs. A record was kept of the total number of hatched eggs found on each tree. At the outset there was some confusion in this record due to parasitism by *Telenomus quaintancei* Girault. This parasite was abundant about New Brunswick. Fortunately one can distinguish a hatched parasitized egg from a normal hatched egg by the larger opening at the blunt end of the egg and by the presence of two dark-colored flattened bodies which occur inside of one surface of the hatched or unhatched parasitized eggs. The dark fat-like bodies may be seen through the thin outer shell. The parasitism of the eggs was largely prevented by holding the eggs in the paper bags until 24 hours before they were ready to hatch and then placing the eggs on the tree so that they were between the paper and the trunk of the tree.

Table 1 summarizes the results of these experiments. The columns from the left to the right show the number of the experiment, the type of protector used, the material placed in the trough, the number of normal hatched eggs, the larvæ in the tree below and above ground, the percentage of newly hatched larvæ to enter the tree when compared with the number of normal hatched eggs, the average percentage of larvæ entering trees where similar protectors were used, and the percentage of reduction with each group of similar protectors.

As the table gives us the results, only a few points will be discussed. In the first place, it should be noted that a number of larvæ entered the tree above ground when protectors were present. Most of these entered directly below the seal of the protector. In no case was there any evidence to show that the larvæ had penetrated the paraffine seal rather than crawl over the protector to the point of entrance. Our experience with the Scott's tree protectors makes us believe that

the young larvæ crawled over the protector to reach the tree. In former experiments it has been shown that the larvæ have a strong tendency to enter the tree above ground when a paper collar is present. This habit may be due to the fact that moisture collects under the protector and softens the bark, making it favorable for larval entrance.

Since the number of eggs that actually hatched on each tree varied considerably, the only way to ascertain the relative effectiveness of each protector was to compare the number of small larvæ found in each tree with the number of hatched eggs, and thus determine the percentage that entered. The various average percentages to enter the tree where protectors were present were 0.7 to 9.6 per cent, while 26 per cent entered the check trees. In all of the experiments one or more larvæ entered all of the trees. How this was accomplished in experiments 26 and 27 where the trough was filled with oil is unknown. It is possible that one or more of the many newly hatched larvæ crawled down the cone, fell off upon the soil close to the tree, found the tree by chance and entered. Several experiments conducted this past season show that a small percentage of larvæ hatching from eggs placed 4 inches from the base of the tree on the soil will find the tree and enter. Another explanation for the above may be that a female deposited a few eggs on the tree below the cone. The author questions this possibility, because the lower margin of the protectors was usually less than 33 inches from the soil, and furthermore the dirt was piled up about the base of the tree to a height at least equal to the lower margin of the protector.

The type B tin protectors with oil in them gave the best results, 93 to 97 per cent reduction, while the type B roofing paper protectors with and without materials in the trough, gave 66 to 85 per cent reduction. Type A protectors gave 78 to 90 per cent reduction. The experiments are not extensive enough to determine the relative value of the various dry substance used in the trough, but taking the experiments as a whole there is a decided reduction in the infestation. In all cases the reduction is greater than that brought about by the Scott's tree protector (experiments 28 and 29, and former experiments). The results indicate that a trough added to a protector is desirable.

Three trees were protected by a heavy canvas (drilling cloth). A square cloth (3 by 3 feet) was cut as shown in figure 4 and placed about the base of the tree. A string was used to tie the cloth to the tree 3 to 5 inches from the ground. The overlapping edges of the cloth were sewed with two seams. The outer margin of the cloth was covered with 2 inches of soil. Enough slack was left in the cloth between the soil and the tree to permit the tree to sway with the wind without tearing the cloth. When the cloth was in position about the tree it was impregnated with melted paraffine. This coating of paraffine was repeated several times in a few weeks, for cracks developed in

the coating. Table 1 (experiments 7 to 9) shows that a few larvæ entered these trees. It is probable that they found cracks in the paraffine sufficiently large to permit them to reach the tree, or they may

TABLE 1

Results of protector experiments for the control of the peach-tree borer at the College Farm, 1919

Number	Protector	Chemical	Hatched Eggs	Larvæ below ground	Larvæ above ground	Per cent Larvæ that entered tree	Per cent average entrance	Per cent reduction
1	check	....	50	17	.....	34.0		
2	check	....	46	6	.....	13.0		
3	check	....	90	22	.....	26.0		
4	check	....	80	11	.....	16.0	26	
5	check	....	20	6	.....	40.0		
6	check	....	50	14	.....	28.0		
7	cloth	....	109	2	.....	1.8		
8	cloth	....	55	2	.....	3.5	2.1	92
9	cloth	....	57	6	.....	1.0		
10	Type A......	Sand	72	3	.....	4.1		
11	Type A......	Sand	128	2	1	2.3	26.0	90
12	Type A......	Sand	138	2	.....	1.4		
13	Type A......	Empty	107	4	.....	3.7		
14	Type A......	Empty	180	5	10	8.0	5.8	78
15	Type B-p....	Empty	62	1	.....	1.6		
16	Type B-p....	Empty	163	2	.....	1.3	3.9	85
17	Type B-p....	Empty	145	11	2	8.8		
18	Type B-p....	Sand	98	4	1	5.1		
19	Type B-p....	Sand	78	6	4	12.8	8.9	66
20	Type B-p....	$CaCl_2$	144	6	2	5.5		
21	Type B-p....	$CaCl_2$	168	3	1	2.3	3.8	86
22	Type B-p....	NaCl	108	11	.....	10.2		
23	Type B-p....	NaCl	91	3	1	4.4	7.3	72
24	Type B-t....	Empty	166	3	.....	1.2		
25	Type B-t....	H_2O*	90	8	.....	8.8	4.3	84
26	Type B-t....	"Scalecide"	148	3	.....	20.0	2.0	93
27	Type B-t....	Kerosene	143	1	.....	0.7	0.7	97
28	Scott's	....	92	4	7	12.0		
29	Scott's	....	122	5	4	7.3	9.6	64

* Evaporated or leaked out.

have crawled out to the point where the cloth was covered with dirt. Where the cloth was in contact with the ground it rotted in four to five weeks and became more porous.

Protectors

The above cone protectors possessing troughs give promise of materially reducing or preventing a peach-tree-borer infestation, provided they are properly adjusted about the tree and tightly sealed for the entire season (June 15 to September 15). There are a number of serious objections to such protectors. The original cost is too great; they are difficult to apply and they also need constant attention in order to maintain a perfect seal. Furthermore, they could not be placed on low-headed trees or on trees with the trunk arising at an angle from the ground.

In studying the problem of finding a practical and an efficient protector the following important points must be considered: the response of the larvæ to the protector and the influence the protector may have on the growth of the tree; also how the growth of the tree, the swaying of the tree in the wind and the structure of the basal portion of the tree, will influence the protector and its seal. From a practical standpoint the original cost of the protector, the cost of application, and its maintenance must be small. Furthermore, the protector should be easy to apply and maintain its position for a period of 90 days. The above points and others make the problem of developing a satisfactory mechanical protector for the peach-tree borer a difficult one.

The Strawberry Root-Worm, a Serious Pest on Roses in the Greenhouse

ALVAH PETERSON

In July, 1917, H. O. May, of Summit, N. J., called Dr. T. J. Headlee's attention to the fact that a small beetle was feeding on his Hoosier Beauty and Ophelia rose plants. On examination it was observed that the beetles were riddling the foliage and also feeding on the stems, buds and the new growth. Specimens were collected at that time and the insect was determined by a former assistant to be *Typophorus excavatum* Linn. Later on the specimens were sent to C. W. Leng and he determined the former as *Typophorus* (Paria) *canellus* Fab., var. *quadrinotatus* Say. Specimens were sent also to C. A. Frost and his reply was: "They are *Typophorus canellus* near the variety *quadrinotatus* of Say." Messrs. Weigel and Chambers in their recent publication (1) have determined the beetle to be *Paria canellus* Fab. From the above statements it is evident that there is some uncertainty in respect to the correct name of the species. The

author will not attempt to straighten out the confusion of names in this report. For the sake of reference the name *Typophorus canellus* will be used.

Extent and Nature of the Injury

To date *T. canellus* has been found in only one rose greenhouse in New Jersey. Outside of New Jersey Weigel and Chambers have found it in greenhouses at Alexandria, Va., Richmond, Ind., Washington, D. C., and in a number of rose houses near Philadelphia.

The adults of *T. canellus* in New Jersey have been found outdoors feeding on strawberries, raspberries, blackberries and rose bushes, while the larvæ have been found on strawberries. Other investigators report that the adults have been found on blackberries, juniper, crab apple, apples and other wild and cultivated plants. In the greenhouse at Summit, the adults have severely attacked the Ophelia, Russel and Hoosier Beauty varieties and possibly less severely White Kilarney and Columbia varieties. Other varieties, such as Sunburst, Aaron Ward and Premium, growing in the infested bouses, have not been attacked to any marked extent.

The greatest injury at Summit occurred during the summer of 1917 and 1918. During these two seasons the leaves of the above varieties were badly riddled and the young shoots severely scarred.

The adults make small irregular holes through the leaf. Some of the punctures do not completely penetrate the entire leaf. The upper or lower transparent membranes being unbroken, when the feeding punctures are plentiful, the leaves have a shot-hole appearance. The adults also feed on the young shoots and the green stems, and occasionally on the young flower buds. The feeding marks on the stems give the canes a scarred appearance. At times the scarring is severe enough to girdle the cane completely. When the young flower buds are attacked the mature flowers are distorted.

The adults usually feed at night, on cloudy days or when the sun is low. When the sun is shining brightly they seek shelter. Many of them crawl under a leaf, into the soil, or into a dead curled leaf on the bush or on the soil.

Outdoors the larvæ are known to do serious damage to the roots of strawberries and other plants, consequently a careful watch was kept for the appearance of any root injury on rose bushes which might be attributed to the larvæ in the soil. Only once did we note root injury which we now believe was due to the larvæ. During 1919 a severe outbreak of beetles occurred in an isolated house. After the plants were cut back and permitted to renew their growth in the usual manner 10 per cent or more died and many others developed into weak plants. At first this loss was attributed to some mistake

in the culture practiced. Shortly after this loss occurred we learned from Mr. Weigel and Mr. Chambers that a number of growers about Philadelphia had lost as high as 75 per cent of their bushes by root injury due to the larvæ. If other growers have experienced such great losses by the larvæ it is altogether probable that the 10 per cent loss at Summit during 1919 was due to the larvæ feeding on the roots previous to the severe outbreak of the adults. For some unknown reason the most important injury at Summit has been done by the adults above ground while in other greenhouses about Philadelphia rose-bushes have been severely injured above and below ground.

The source of the infestation at Summit is not definitely known. After the beetles were discovered in considerable numbers indoors in 1918 and 1919 we examined and found adults and feeding punctures on foliage of strawberries and raspberries in a garden near an infested house. Some of these plants in 1916 were secured from a nursery where the beetle has been reported to be present in considerable numbers. So far as is known no soil was ever taken from this garden into the greenhouse. We do not know definitely that this insect was present in the garden before the indoor infestation took place, consequently we cannot say that the beetle went from the garden into the greenhouse or vice versa. The heaviest infestation was first found in 1917 on four benches of Hoosier Beauties, and to some extent in benches of Ophelia and Russels in the same house. The florist informs us, that the Hoosier Beauties were purchased from a plant distributor in 1916, who, it is reported, was troubled with this pest the same year. Probably the infestation at Summit came in with the new lot of Hoosier Beauty plants.

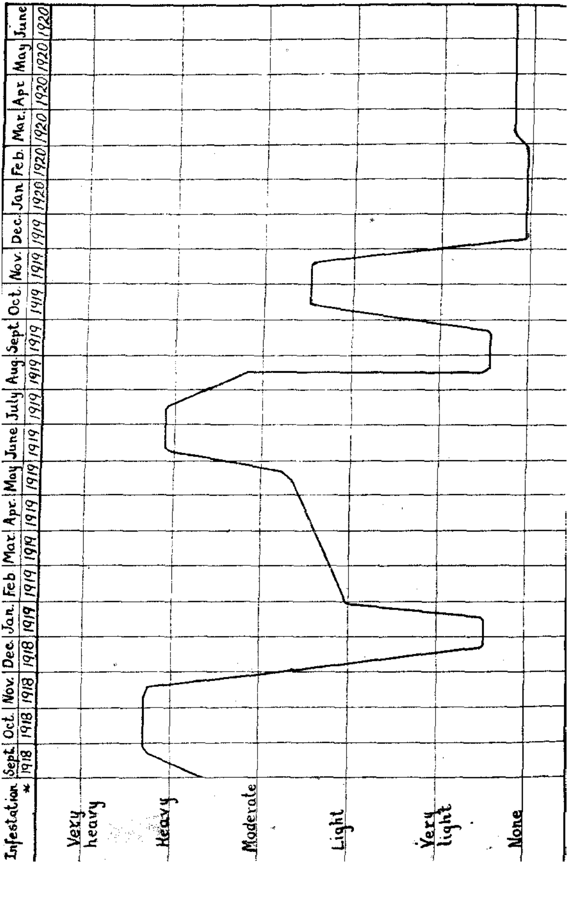
Observations at Summit

Late in September, 1918, Dr. Headlee assigned to the writer the problem of working out the life history and control measures for *T. canellus* at Summit. Previous to this time the adults had been exceedingly abundant during June and July, 1918, and the plants suffered a decided set-back. The stems were short and the flowers were by no means normal. In September the author carefully examined the soil in several infested benches of Hoosier Beauties and found 1 to 5 larvæ or pupæ about each plant. No larvæ were found after October 15 and only a few pupæ were seen the last two weeks in October. From September until early in December the adults were plentiful, but after this period only an occasional beetle was seen on the bushes. Most of them were in the ground hibernating. One of the favorite locations for hibernation in the greenhouse is some point adjacent to the crown of the plant one or two inches in the soil.

During the last week of January, 1919, some of the adults came out of hibernation and attacked White Kilarney bushes at one end of a house which previously had not shown a serious infestation. The adults continued to appear during February, March, April and early May in small spasmodic outbreaks in several places in different houses. The largest single spring outbreak occurred early in March (fig. 1). At no time were the adults abundant, yet they were present in sufficient numbers to do some harm. Late in May and early in June the adults appeared in large numbers and they continued to be abundant throughout June and July, but early in August they started to disappear and by August 20 had almost completely disappeared. Previous to and during the heavy outbreak in June a number of larvæ and pupæ were found in the soil about Ophelia and Russel roses. No larvæ or pupæ were found after June 25. The adults appeared again the last weeks in September, 1919, but there were only a few present compared with September, 1918. By November 15 practically all of the adults disappeared. From December 1, 1919, to February 20, 1920, no adults were seen. A very few appeared (less than one per bench was found) the last week in February. During March, April, May and June only an occasional beetle was found in any of the houses which in previous years were heavily infested.

Figure 1 summarizes the abundance of the adult from September, 1918, to July, 1920. The records for the chart are based on the number of adults caught from each of several benches. Collections were usually made by beating the bushes early in the morning or on cloudy days. Most of the collections were made every 7 to 14 days by the author, the information obtained from the florist on the number of adults he himself caught by beating also was of decided value. The chart shows the presence of some or many adults on the bushes at all times from September, 1918, to December 1, 1919. In 1918 the adults were present on the bushes every month in the year.

The chart indicates the presence of two generations each year, at least there seems to be two periods when the adults appear in great numbers. The second generation was always smaller than the first. The adults emerge from their hibernating quarters some time during the spring and partake of some food. The females deposit their eggs and the majority of the adults from these eggs emerge late in May or in June. The adults appearing in June in turn deposit eggs and the majority of the adults from these eggs emerge late in September. The adults appearing in September feed to some extent on foliage and then seek hibernation quarters. No eggs were ever seen from August 15 to February 15 and no young larvæ were ever seen from September 1 to February 1. Mr. Chambers reports that he has seen full-grown larvæ and pupæ in March and April. It is probable that some adults do not follow the above schedule.


Infestation
*
Sept. 1918
Oct. 1918
Nov. 1918
Dec. 1918
Jan. 1919
Feb. 1919
Mar. 1919
Apr. 1919
May 1919
June 1919
July 1919
Aug. 1919
Sept. 1919
Oct. 1919
Nov. 1919
Dec. 1919
Jan. 1920
Feb. 1920
Mar. 1920
Apr. 1920
May 1920
June 1920
Very heavy
Heavy
Moderate
Light
Very light
None

Adults

The adults of *T. canellus* collected at Summit were small dark-colored beetles 3 to 4 mm. long. Each elytron possesses two large black spots with a smaller dark spot located near the lateral margin. The prothorax is dark-colored (almost black) with reddish-brown areas near the meson on the cephalic and caudal margins. The head has a dark reddish-brown tinge. All of the adults collected have been dark in color, but not black. Outdoors and in other greenhouses this species seems to vary considerably in color. This variation has not been characteristic of the specimens collected at Summit. When the adults emerge from the pupæ they are light in color, but upon exposure to environmental factors they soon become dark. A detailed description of the adult will not be given in this report. Plates 1 and 2 (*figs. 5, 8, 9, 10, 13, 14, 15, 16, 17, 20, 21, 23, 24 and 25*) show various portions of a female adult. No male adults have been seen at any time in our three years of observation with this species. Numerous adults which appeared to be males and had all the characteristic habits of a male have been dissected and in all cases the individuals have always turned out to be immature or mature females.

No attempt will be made to discuss in detail the various figures of the adult parts, a few, however, will need some explanation. The dorsal view of a female adult in figure 5 (pl. 1) shows ring-like marks about each puncture on the left elytron. These marks can be seen only when the light passes through the elytron. Figure 8 is a cephalic view of the head of an adult with the right eye removed, showing the ocular sclerite. Figure 15 (pl. 2) shows an immature group of ovaries. The ovaries are in this condition when the adults first emerge from the pupæ. So far as observed they do not develop to any extent until the adult has consumed some food. Numerous adults were examined from September to December in 1918 and 1919 and all of them had their ovaries in this immature condition. During January the ovaries increase considerably in size and by the time the adults start to deposit their eggs the ovaries fill the entire abdominal cavity and distend the abdomen considerably.

Figure 16 (pl. 2) is a lateral view of the evaginated posterior portion of the alimentary canal of a female. Inside of the tube the intestine proper and the common oviduct are shown by dotted lines. Figures 16 and 20 (pl. 2) show the tube evaginated somewhat beyond the normal condition in order to show the point where the intestine and the common oviduct join. In the ventral view (pl. 2, fig. 20) of the evaginated common tube note the median paddle-shaped structure (Z), the two small palpi (pl) with chitinized pieces (ch) at their proximal ends, the median chitinized needle-shaped structure (pl. 2, fig. 16, x) with one end attached to the inner surface of the evaginated common tube and the other end free, and the V-shaped chitinized rods (u) present at the distal end on the dorsal aspect of the common tube (when evaginated), only one arm of this

V-shaped structure is seen in figure 16. The above pieces undoubtedly have some function in egg deposition. When a female deposits an egg she protrudes the alimentary canal by turning it inside out to the point where the common oviduct joins the digestive tract. When fully extended it is from 0.25 to 1.3 times the length of the body or longer. By means of this arrangement she can deposit eggs in cracks or crevices or on the under-sides of objects. The adults seldom use their wings for flying. They usually walk from one place to another. When the adults are feeding or crawling over the plant they will generally feign death when disturbed. In doing this they draw their legs up to their body, drop to the ground and remain in this posture for a short time.

Eggs

The eggs of *T. canellus* are normally a light lemon yellow when deposited. They are rounded at the two ends and average 0.954 mm. in length by 0.286 mm. in breadth. The eggs are usually deposited in groups, two to five in each group. Mr. Chambers has seen 12 or more in one group. Several groups of eggs may occur in one lot, as shown in figure 22. About each group the female places a white or grayish frothy substance which may be dark-colored when mixed with dirt. At times the white or grayish coating completely covers all of the eggs. So far as is known this substance comes from the mouth. No females have been seen depositing this frothy substance, but females have been seen with a frothy substance oozing from their mouth. This may be the same substance that they place about the eggs. In our laboratory experiments it was observed that the eggs were deposited on dead leaves, under pieces of dead wood or on the sides and bottoms of glass dishes. Mr. Chambers reports finding eggs in the greenhouse inside of dead curled leaves on the bushes. These leaves fall to the ground and the larvæ escape into the soil.

On February 4, 1919, we found the first group of eggs at the laboratory. The ten adults in the dish where the eggs were first seen continued to deposit eggs until April 22, a period of 80 days. The length of time one female may deposit eggs was not determined. The majority of the eggs hatched in 6 to 10 days, but a few required a longer time. In some instances this variation occurred among eggs in the same lot.

PLATE 1

Figures on this plate drawn to same scale

FIG. 1. EGG OF TYPOPHORUS CANELLUS.
FIG. 2. LATERAL VIEW OF A FULL GROWN LARVA.
FIG. 3. VENTRAL VIEW OF A PUPA.
FIG. 4. DORSAL VIEW OF A PUPA.
FIG. 5. DORSAL VIEW OF AN ADULT. LEFT ELYTRON WITH LIGHT PASSING THROUGH IT SHOWING RINGS ABOUT EACH PUNCTURE.

PLATE 1

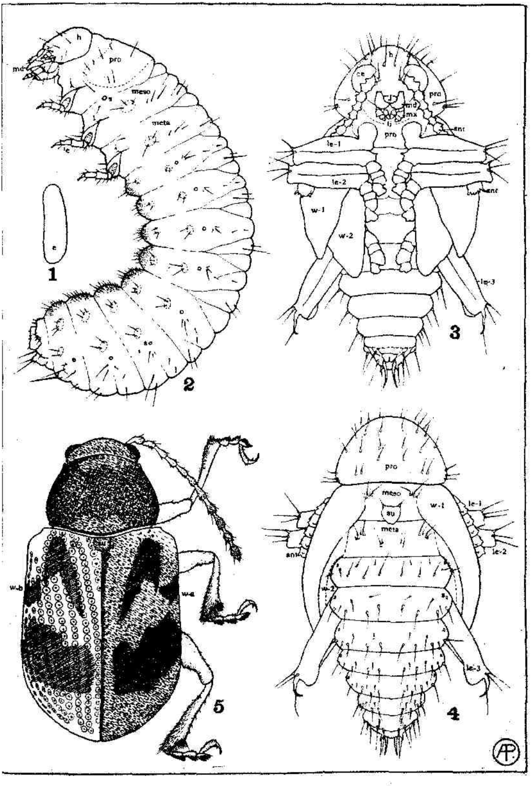

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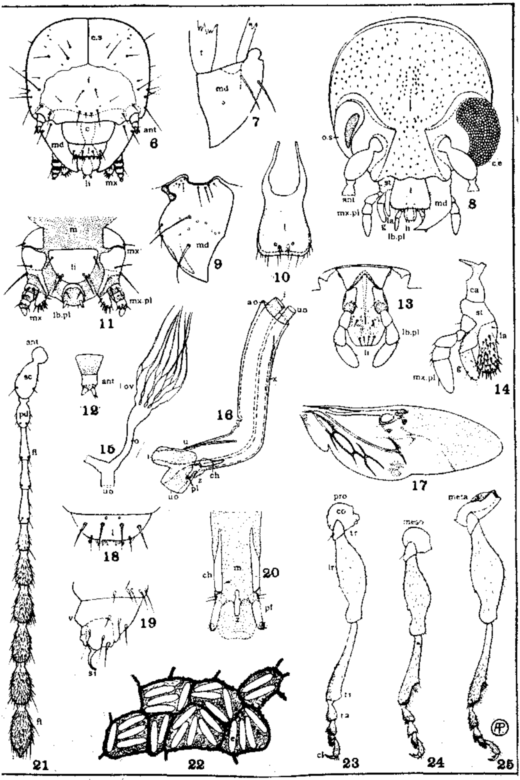
PLATE 2

FIG. 6. CEPHALIC VIEW OF THE HEAD OF A LARVA.
FIG. 7. LEFT MANDIBLE OF A LARVA.
FIG. 8. CEPHALIC VIEW OF THE HEAD OF AN ADULT. THE EXTERNAL PORTION OF THE RIGHT EYE REMOVED TO SHOW THE BROAD SCLERITE ABOUT THE CAVITY.
FIG. 9. RIGHT MANDIBLE OF AN ADULT.
FIG. 10. CEPHALIC ASPECT OF THE LABRUM OF AN ADULT.
FIG. 11. CAUDAL ASPECT OF THE LABIUM AND MAXILLÆ OF A LARVA.
FIG. 12. ANTENNA OF A LARVA.
FIG. 13. CAUDAL ASPECT OF THE LABIUM OF AN ADULT.
FIG. 14. CAUDAL ASPECT OF THE RIGHT MAXILLA OF AN ADULT.
FIG. 15. OVARIES FROM ONE SIDE OF A FEMALE (DECEMBER).
FIG. 16. LATERAL VIEW OF AN EVAGINATED FEMALE INTESTINE AS IT PROTRUDES FROM THE POSTERIOR END OF THE ABDOMEN.
FIG. 17. METATHORACIC WING.
FIG. 18. LABRUM OF A LARVA.
FIG. 19. LATERAL VIEW (LEFT SIDE) OF THE CAUDAL END OF THE ABDOMEN OF A PUPA.
FIG. 20. VENTRAL VIEW OF THE CAUDAL END OF AN EVAGINATED FEMALE INTESTINE AS IT PROTRUDES FROM THE ABDOMEN.
FIG. 21. ANTENNA OF AN ADULT.
FIG. 22. CLUSTER OF EGGS.
FIG. 23. PROTHORACIC LEG OF A FEMALE ADULT.
FIG. 24. MESOTHORACIC LEG OF A FEMALE ADULT.
FIG. 25. METATHORACIC LEG OF A FEMALE ADULT.

ABBREVIATIONS

ant.—antenna
a.o.—united alimentary canal and common oviduct
c.—clypeus
ca.—cardo
ce.—compound eye
ch.—chitinized area
co.—coxa
e.—egg
e.s.—epicranial suture
f.—front
fl.—flagellum
fr.—femur
g.—galea
h.—head
i.—intestine
l.—labrum
la.—lacinia
lb. pl.—labial palpus
le.—leg
le-1—prothoracic leg
le-2—mesothoracic leg
le-3—metathoracic leg
li.—labium
m.—membrane
md.—mandible
me.—mentum
meso.—mesothorax
meta.—metathorax
mx.—maxillæ
mx.pl.—maxillary palpus
o.s.—ocular sclerite
ov.—ovaries
o.—oviduct
pd.—pedicel
pl.—palpus
pro.—prothorax
s.—spiracle
sc.—scape
si.—spine
st.—stipes
su.—scutellum
t.—tendons
ta.—tarsus
ti.—tibia
tr.—trochanter
u.—chitinized V-shaped rods
uo.—common oviduct
v.—ventral
w-1—mesothoracic wing
w-2—metathoracic wing
w-a—appearance of elytron when light is reflected from it
w-b—appearance of elytron when light passes through it
x.—chitinized needle shaped organ
z.—chitinized lobe at end of evaginated tube

PLATE 2



Larvæ

The larva (pl. 1, fig. 2) resembles a small white grub. The full grown larva is 4 to 4.5 mm. long and about 1.25 mm. wide, or approximately three times as long as wide. The abdomen is nearly twice as long as the head and thorax combined and the diameter of the first seven abdominal segments is as great as or a trifle greater than the diameter of the mesothorax or metathorax, while the terminal segments of the abdomen are much smaller. Each segment of the abdomen, except the last, possesses two or three folds on the dorsal aspect and two spiracles. The larva when full grown is entirely white except the head and the dorsal aspect of the prothorax which are yellowish brown. Figures 2, 6, 7, 11, 12, and 18 in plates 1 and 2 show the detailed structure of the various parts. So far as possible the exact location of the larger setæ on the parts is shown in the drawings.

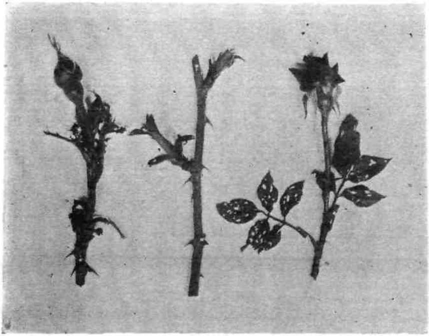
In our experiments we never reared an individual beetle from the egg to the adult, but the various stages have been reared to completion or thereabouts. Larvæ hatching from eggs were reared in moist soil until they appeared to be full grown, but in no case did they pupate normally. The time required was 60 to 70 days. The larvæ in the above experiments were not fed on roots of plants but were given rose leaves, and they ate only a small amount of the mid-ribs of fresh leaves. A careful study should be made to determine the exact life cycle of this beetle. It is possible that the first brood each season requires a longer time to reach maturity than the summer forms.

In the greenhouse at Summit the larvæ were found in the soil usually within 2 inches of the surface. Where the infestation is exceedingly heavy they may be found anywhere in the bench, according to Mr. Chambers. Since we did not find the larvæ much below the 2-inch zone at Summit, this may account for the fact that little or no root injury has occurred in this greenhouse. In the upper layers of infested soil it was noted that new or young roots were wanting.

Pupæ

The pupa is white in color when it is newly formed. The eyes, mouth-parts and the mesothoracic wings take on a darker tinge as the time approaches for the adult to emerge. The pupa is 4 to 4.5 mm. long and its greatest diameter is approximately 2 mm., if one measures the distance between the distal ends of the femora of the metathorax. The pupa is found in the soil in a round earthen cell a trifle larger than the pupa. So far as is known this cell is not lined with slik. The pupa when disturbed vigorously wiggles its abdomen. The general form of the pupa resembles that of the pupæ of a number

PLATE 3



Photographs of Injury on Leaves, Buds and Shoots of Roses Caused by Feeding Habits of the Adults of the Strawberry Root-Worm.

of the *Chrysomelidae.* No description will be given of the various parts; figures 3, 4 (pl. 1) and 19 (pl. 2) show the important aspects. Observe the size and arrangement of the setæ, the stout irregular spines at the distal ends of the femora of the metathoracic legs and the two curved spines projecting caudo-dorsa at the caudal end of the abdomen.

T. canellus is in the pupal stage 8 to 11 days. At least this was true at Summit in September and October, 1918. Considering the information at hand the length of the life cycle of *T. canellus* appears to be 80 to 90 days. However, this may vary considerably under different indoor conditions.

Control Measures

Dr. T. J. Headlee and the author have tried various control measures for this beetle in the rose greenhouses at Summit. At the outset Dr. Headlee conducted several fumigation tests with hydrocyanic acid gas and also a few experiments with several dusts.

Fumigation

In July, 1918, Dr. Headlee learned from his experiments that the minimum dosage of hydrocyanic acid gas required to kill the beetles will also injure the rose bushes. In one greenhouse-experiment late in July, 1918, 1½ ounces of sodium cyanide to 1,000 cubic feet of space was used with 20 minutes' exposure. Immediately after this treatment all of the adults appeared to be dead, but in 24 hours 90 per cent or more had recovered and they appeared to be normal in all respects. The plants in this treatment were seriously injured. The new shoots were killed back 6 to 12 inches. Furthermore, the plants did not recover their normal growth for a considerable period of time. The florist claimed they were set back 6 to 8 weeks.

Other investigators have used greater strengths of sodium cyanide and killed 97 per cent of the beetles. Messrs. Weigel and Chambers report:

> The maximum dosage which roses are known to withstand was therefore employed. The exposure lasted 2 hours, using 2 ounces per thousand cubic feet. Less than 3 per cent revived from the effects of the gas, or expressed in other words, a killing of 97 per cent of the adult beetles resulted from the above fumigation. As was anticipated, practically all of the tender growth was more or less burned. This injury, however, was only temporary since at the expiration of 3 weeks the plants were in excellent growing condition and had produced an abundance of newly forced growth which was attributed to the stimulating effects generally following fumigation with hydrocyanic acid gas.

Dr. Headlee's preliminary trials at the laboratory show that 2 or 2.5 ounces of sodium cyanide per thousand cubic feet of space will

kill all of the beetles in one hour's exposure and in some cases less than one hour. Probably the best time to fumigate for the beetle may prove to be during the latter part of the drought period; late in June or early in July. At this time the plants are quite dry and also more resistant than during the active growing season. Furthermore, any injury caused by the fumigation more than likely can be removed when the plants are cut back.

Sprays

In addition to the fumigation experiments, Dr. Headlee advised the florist to dust the infested beds thoroughly with powdered hydrated lime and with a combination dust composed of hydrated lime and arsenate of lead. When the plants were thoroughly dusted the injury on the foliage was materially reduced, but so far as is known the adults were not killed. The chief objection to dusts in a rose greenhouse is the fact that florists syringe their rose bushes once or twice a week and this destroys the dust coating. To maintain the dust coating the plants were redusted after each syringing.

The author has not carried on extensive greenhouse experiments with various dusts or sprays, but he has conducted a number of laboratory tests which show the response of the adult to various poisons in liquid and dust form; lead arsenate, calcium arsenate, magnesium arsenate, paris green, lime, sulfur, hellebore and derris. Most of these experiments were conducted in small cages placed about individual plants or in small glass dishes big enough to hold several rose leaves and 10 to 25 adults. The author had intended to use several of the promising mixtures this season in the greenhouse, but the almost complete disappearance of the beetle at Summit has curtailed his plans for further study of this pest. Even though the following laboratory tests were not conducted on a large scale they may be of some value to investigators or growers troubled with this pest.

A number of liquid sprays were tried out and it was soon learned that a spreader is necessary to get a good coating on rose foliage. Soap was used as a spreader whenever it was possible, otherwise a 50-50 mixture of casein-lime was used. This is not as good as soap, but it helps to lower the surface tension of water (sprays) and thus spreads the poison spray better.

The florist at Summit sprays his rose bushes with paris green, 4 ounces to 50 gallons of water plus 4 pounds of brown sugar to control thrips. When this was applied we questioned its influence on the beetles which were feeding on the foliage. A number of experiments were conducted with paris green at the rate of 4 and 8 ounces to 50 gallons of water. Each strength was tried by itself and in combination with 4 and 8 pounds of brown sugar to 50 gallons of spray, and

also the above combinations with each strength of paris green were combined with casein-lime at the rate of 2 pounds to 50 gallons of spray. This made 10 different sprays. The experiments were conducted in petri dishes, each dish containing several sprayed leaves and 10 adults. Sprayed fresh leaves were inserted whenever the old leaves were no longer relished by the adults. Observations made 8 days after the experiments started showed considerable feeding and a 10 per cent or smaller kill wherever the 8 ounces of paris green was used, while the sprays containing 4 ounces of paris green showed little or no kill. These tests and others of a similar nature show that paris

TABLE 1

Effect of various arsenical sprays (alone or combined with brown sugar or casein-lime) on 10 adults of *T. cancellus;* the sprays sprayed on fresh rose foliage and the leaves placed in glass dishes at the laboratory in July, 1918

No.	Sprays	5 days dead	10 days dead	Total holes in leaves
1	Lead arsenate, 2 lbs. to 50 gal.	0	0	Numerous
2	Lead arsenate, 2 lbs. to 50 gal., plus brown sugar, 4 lbs.	4	4	Few
3	Lead arsenate, 2 lbs. to 50 gal., plus casein-lime, 2 lbs.	0	2	Moderate
4	Paris green, 1 lb. to 50 gals.	2	2	Numerous
5	Paris green, 1 lb. to 50 gal., plus brown sugar, 4 lbs.	3	4	Moderate
6	Paris green, 1 lb. to 50 gal., plus casein-lime, 2 lbs.	1	1	Moderate
7	Calcium arsenate, 2 lbs. to 50 gal.	2	4	Few
8	Calcium arsenate, 2 lbs. to 50 gal., plus brown sugar, 4 lbs.	5	8	Few
9	Calcium arsenate, 2 lbs. to 50 gal., plus casein-lime, 2 lbs.	0	1	Moderate
10	Magnesium arsenate, 2 lbs. to 50 gal.	0	6	Few
11	Magnesium arsenate, 2 lbs. to 50 gal., plus brown sugar, 4 lbs.	2	5	Few
12	Magnesium arsenate, 2 lbs. to 50 gal., plus casein-lime, 4 lbs.	0	3	Moderate
13	Check	0	0	Numerous

green at the rate of 4 to 8 ounces to 50 gallons of water does not kill the adults in sufficient quantity to warrant its use against the beetle. Furthermore, 8 ounces of paris green to 50 gallons of water may burn rose foliage.

Several series of liquid spray experiments were conducted with lead arsenate, paris green, calcium arsenate and magnesium arsenate

alone and in combination with brown sugar or casein-lime. Table 1 shows the results obtained in one of these series. There is considerable variation in the results with the various arsenicals used yet no arsenical gave 100 per cent kill in 10 days. It is interesting to note the fact that in all cases but one the greatest kill with each poison occurred where the brown sugar was combined with the spray. This sweet material is apparently an attractive agent. It probably induces the beetle to consume more poisoned foliage than it would normally consume. Another series of experiments, similar to the one just discussed, was conducted in petri dishes with lead arsenate, calcium arsenate and paris green, each by itself and each combined with brown sugar. In this series the adults were permitted to feed on the sprayed foliage for 4 days, and then they were given fresh untreated leaves. Ten per cent or less of the adults were dead in 10 days after the experiment started, and the fresh foliage was readily consumed.

Derris was also applied in liquid form on the foliage in strengths varying from 1 to 4 pounds to 50 gallons of water. Brown sugar was also combined with some of the strengths and in some sprays soap was used as a spreader. All of the experiments ran for 10 days and no kill resulted. The foliage in all of the dishes was riddled with feeding punctures.

Dusts

Table 2 shows the effect of several poison dusts on the beetle. These experiments were conducted in glass dishes. Ten adults were placed in each dish with newly dusted fresh rose leaves. Dusted fresh leaves were placed in the respective dishes every 24 hours for 4 days. After the fourth day untreated fresh leaves were inserted daily for 10 or more days. The table records the effect of the various products on the beetles after 4 and 10 days. Some of the dusts were given three trials and the results obtained with each substance were similar. The greatest kill, 96 per cent, resulted with derris while a combination of lead arsenate, 1 part; sulfur, 1 part, and hydrated lime, 1 part, showed the next highest kill, 63 per cent. The derris may have killed many of the beetles as a contact insecticide, for adults rolled in derris will die. In the above experiments a record was kept on the amount of feeding which took place. This was determined by the number of holes made in the leaves. The results show that whenever a lead arsenate or a derris dust was used the number of holes per adult for the first 4 days was 0.4 to 2.7, while in the check dishes the holes averaged 7 per adult. After the poisoned leaves were removed the effect of the poison continued to influence the amount of feeding. Ten days after experiments were started all of the dishes where the dusts contained lead arsenate or derris alone showed 1 to 2.7 holes per adult while the checks showed 15 holes per adult. In the experiments with hellebore, hydrated

lime, and paris green (1 part, combined with hydrated lime, 25 parts), the feeding increased considerably after the poisoned foliage was replaced by fresh foliage, but in no instance did it equal the amount of feeding in the checks.

TABLE 2

Effect of various poison dusts (alone or combined with hydrated lime or sulfur) on adults of *T. cancellus*; the dusts dusted on fresh rose foliage and the leaves placed in glass dishes at the laboratory

No.	Dust	Number of Adults	4 days		10 days		
			Dead	Holes per Adult*	Dead	Percentage Dead	Holes per Adult**
1	Hydrated lime	30	0	1.7	9	30	5.0
2	Lead arsenate 1 pt., lime 5 pt.	30	1	2.7	14	46	2.7
3	Lead arsenate	30	9	0.4	16	53	1.5
4	Lead arsenate 1 pt., *sulfur 1 pt.*	*30*	*10*	*0.4*	*17*	56	*1.4*
5	Lead arsenate 1 pt., sulfur 1 pt., lime 1 pt.	30	11	0.5	19	63	1.3
6	Paris green 1 pt., lime 25 pt.	10	0	1.0	0	0	12.0
7	Derris	30	3	0.6	29	96	1.0
8	Derris 1 pt., lime 5 pt.	20	1	1.4	12	60	2.3
9	Derris 1 pt., sulfur 1 pt.	10	0	0.4	2	20	3.0
10	Hellebore	20	0	1.6	0	0	7.7
11	Check	30	0	7.0	0	0	15.0

*Treated leaves
***Untreated leaves*

One series of individual caged plants during November, 1918, were dusted with (A) derris; (B) lead arsenate 1 part, sulfur 1 part, and lime 1 part; (C) lead arsenate 1 part and lime 5 parts; (D) hydrated lime, and (E) a check, in November, 1919. Twenty-five adults were placed in each cage and in 10 days the following observations were made. The check bush (E) possessed 60 leaves and 40 were injured. Twenty-five per cent of the injured leaves showed 25 or more holes per leaf. The number of holes on the different leaves was somewhere between 1 and 50. The plants dusted with derris (A) showed no injury whatsoever. The plants dusted with a combination of lead arsenate, sulfur and lime (B) showed 3 injured leaves possessing a total of 12 holes. The plants dusted with lead arsenate and lime (C) showed 5 injured leaves possessing a total of

22 holes. The plants dusted with lime alone (D) showed two injured leaves with a total of 25 holes. The above experiments were conducted the last 3 weeks in November, 1919. At this time of the year many of the adults are going into winter quarters, consequently some of the adults were found in the soil or hibernating under old dead leaves. These probably consumed little or no foliage. Only one or two dead adults were seen on the bushes at the end of 10 days in experiments (A) and (B) and only 50 per cent of the original number were found. In the derris experiment only 5 living adults were seen. The above experiments may have been conducted too late in the season to give a satisfactory test.

Some of the above dusts brought about a considerable amount of kill and a decided reduction in the amount of injury. These preliminary experiments indicate that some dust combinations, if properly applied in the greenhouse, might be of considerable value in controlling this pest. The author is of the opinion that the most satisfactory time to dust the rose bushes is in the month of June or July when the adults are abundant and when the plants are in the drought period. If all of the plants in the infested house were kept thoroughly coated for several weeks it is probable that the numerous hungry adults which make their appearance late in May and in June would consume the poisoned foliage and be killed. Dusting plants during the growing season is apt to be unsatisfactory, especially if the grower syringes the bushes every few days. A thorough syringing of the bushes requires a redusting if the dust coating is to be maintained.

Soil Treatment

In our observations at Summit the vast majority of the larvæ and pupæ were found ½ to 1½ inches from the top surface of the soil. Since the majority of the larvæ were located near the surface it was thought that a small amount of sodium cyanide, nicotine or some similar substance might kill the immature stages and not injure the rose bushes. After our treatments had been made Mr. Chambers informed me that he had found larvæ in numbers 6 inches deep in the soil. If this is a general rule in severely infested benches, then it will be necessary to penetrate all portions of the soil with the soil fumigant in order to eliminate the larvæ in the soil.

Sodium Cyanide

Our former experience on the use of sodium cyanide against wireworms in the soil gave us some information which was of value to us in the greenhouse work. Wireworms in 6-inch pots or in shallow benches are killed with sodium cyanide at the rate of 75 to 100 pounds per acre, consequently it was thought that this dosage might be

effective with the larvæ and pupæ of *T. canellus*. One hundred pounds to the acre is equivalent to 1.041 gm. to a square foot, and each rose bush occupies about one square foot of ground.

TABLE 3

Effect of sodium cyanide on the larvæ and pupæ of *T. canellus* and on the rose plants when the soil about the roots was treated.
September and October, 1918

Bushes	Sodium cyanide	Water	Larvæ alive	Larvæ dead	Pupæ alive	Pupæ dead	Plants normal	Plants injured	Plants dead
	gm.	pints							
1–5	0.25	2	7	0	6	1	5	0	0
6–10	0.25	4	4	0	9	0	5	0	0
11–15	0.50	2	2	0	4	0	5	0	0
16–20	0.50	4	3	1	5	0	5	0	0
21–25	0.75	2	13	6	4	4	5	0	0
26–30	0.75	4	7	5	6	2	5	0	0
31–40	1.00	2	1	10	1	10	5	5	0
41–50	1.00	4	11	7	8	14	8	1	1
51–55	1.50	2	1	8	1	2	2	1	2
56–60	1.50	4	0	2	5	4	0	2	3
61–70	2.00	2	2	5	4	13	0	0	10
71–80	2.00	4	1	16	1	21	2	0	8
81–85	3.00	2	0	8	0	2	0	0	5
85–90	3.00	4	0	5	0	1	0	0	5
91–95	1.00	1.5	3	3	5	17	5	0	0
96–100	1.00	1	2	2	1	13	5	0	0
101–105	1.00	.5	0	1	1	7	5	0	0
106–110	1.50	1	0	0	0	0	5	0	0
111–115	2.00	1	0	0	0	0	2	3	0
116–120	1.50 to 2.00	dry	0	1	3	2	5	0	0
121–125	check	1–4	5	0	9	0	5	0	0

In experiments 1 to 90, the sodium cyanide was dissolved in water and used at the rate of 0.25, 0.50, 0.75, 1.0, 1.5, 2.0 and 3.0 gm. to a bush. Each strength was used with 2 and 4 pints of water. It was observed that in most instances 2 pints of water per plant was insufficient to soak the soil thoroughly while 4 pints was sufficient. These experiments were conducted on Hoosier Beauty roses during October, 1918. The dissolved cyanide was applied with a watering can. In some of the experiments the upper dry mulch of the soil was scraped to one side and the ground raked lightly before the

treatments were made while some treatments were made with the soil untouched. So far as was observed raking the soil or removing the mulch did not alter the percentage of dead or living larvæ and pupæ.

Table 3 shows the effect of the sodium cyanide on the larvæ, pupæ and rose bushes. To obtain a complete kill of immature stages of the beetle it is necessary to use 3 gm. of sodium cyanide dissolved in 4 pints of water and applied to a square foot of soil. Sodium cyanide at the rate of 0.25 to 0.5 gm. per bush (per square foot) killed few, if any, of the immature stages while 0.75 gm. killed 35 per cent, 1 gm. killed 66 per cent, 1.5 gm. killed 70 per cent and 2 gm. killed 87 per cent. The small variation in the amount of water used (2 to 4 pints) apparently made no appreciable difference in the percentage of dead larvæ and pupæ.

The sodium cyanide had little or no effect on the rose bushes when 0.75 gm. or less was used about each bush. One gram injured a number of bushes and killed one out of twenty. Strengths greater than 1 gm. per bush seriously injured or killed a large number of bushes; 3 gm. per bush killed all of the treated bushes. The first sign of injury is seen in the leaves which dry and wilt. The bushes may become partially or completely defoliated and then recover. The injury may not make its full appearance until several weeks after the treatments are made. The effect is similar to that of plant death by drought. So far as observed the young roots are injured or killed, consequently the plants do not receive a sufficient supply of water and nourishment for the upper portion to function properly.

Since 1 gm. of sodium cyanide in 2 and 4 pints of water killed the plants, another series of plants (experiments 91-110) were treated with 1 gm. of sodium cyanide dissolved in 0.5, 1.0 and 1.5 pints of water per square foot of soil. The percentage of kill of the larvæ and pupæ was approximately the same as when 2 and 4 pints of water were used. No plants were injured in these treatments. This was probably due to the fact that the poisonous liquid did not work through all the soil about the roots. Apparently it penetrated the soil only two or three inches. If the larvæ had been located in the lower portions of the bush they probably would not have been killed with the sodium cyanide.

Five bushes also were treated with dry granulated sodium cyanide at the rate of 1.5 to 2 gm. per bush. The cyanide was sprinkled about the bushes and lightly raked into the soil. This method did not prove to be any more effective than the liquid treatment; however, it might be advisable to give it a more extensive trial.

The above experiments show that small doses of sodium cyanide when applied in water or in granulated form to infested soil will kill the larvæ and pupæ but the strength necessary to kill all of the larvæ and pupæ will also kill or injure the rose bushes. If one

uses extreme care and applies the sodium cyanide in a dry state at the rate of 1.5 to 2 gm. per plant or dissolves 1 to 1.5 gm. in a pint or less of water it is probable that a goodly number will be killed and the bushes will not be injured by the beetles in the immature stages. Undoubtedly the amount of the water present in the soil at the time the applications are made is important. If the soil is comparatively dry the poisoned liquid will be absorbed in the upper dry layer and probably remain there. In the experiments the soil moisture was not definitely measured. It varied some, yet at no time were applications made immediately after the plants had been watered. In most cases they were made 3 or more days after watering and in all of the treatments the bushes were not watered for 5 or more days after treating. After this the plants were watered two or more times per week. The plants in the check plots received the same treatment except for the sodium cyanide, and in all cases the bushes came through in good shape, consequently the injury or kill in the treated plots was due to the sodium cyanide.

Nicotine

The results of our experiments with sodium cyanide indicated that the larvæ and pupa might be killed with some other toxic substance. Nicotine (Black-leaf 40) was considered and given a number of trials during March to June, 1919. To determine the response of the rose bushes to nicotine in the soil, 9 Hoosier Beauty rose bushes were watered (1 liter per plant) with dilute solutions of 40 per cent nicotine on March 8, March 28, April 3 and April 12. Each of the three bushes in the three lots received nicotine at the rate of 1, 2, and 4 cc. to a liter of water. Two other rose-bushes were watered continuously for 6 weeks with a 1 to 500 nicotine solution. All of the plants watered with nicotine solutions showed no injury. In fact their growth and color were somewhat better than of adjacent plants.

On June 6, 1919, the larvæ and pupæ were abundant in several benches of Russell roses. The soil about 21 plants was watered with 1 liter of water per plant, containing 2 cc. of nicotine and 12 plants each received nicotine at the rate of 1 cc. per liter. On June 9 the soil was examined for immature stages. Fourteen living and active larvæ (nearly full grown) and pupæ were found in the soil about the bushes where 2 cc. of nicotine to one liter of water was applied. Also all of the individuals in immature stages in the soil which received 1 cc. of nicotine to a liter of water were alive. On June 9 the soil about 12 more bushes was treated with nicotine at the rate of 4 cc. to a liter of water. These were examined on June 14 and 15 living larvæ and pupæ were found and 1 dead pupa. Strengths greater than 4 cc. to 1 liter were not tried. Greater strengths might

kill the immature stages and not injure the rose bushes, yet the cost would be prohibitive.

The author intended to make use of tobacco dust, paradichlorobenzene, and sodium sulfocarbonate this season, but the almost complete disappearance of the beetle at Summit made this impossible.

Poison Baits

In our investigations on the response of the beetles to arsenicals and other poison it was observed that sweetened substances were readily consumed. This gave us the idea that a sweetened poison bait might be used to control this pest, consequently a considerable amount of time was spent on this phase of the problem. Some interesting facts were discovered on the response of the beetles to poisoned bait, yet no use was found for them.

TABLE 4

Comparative value of various arsenical compounds when used as the toxic agent in the poison baits for 15 adults of *T. canellus;* each substance (powder form) used at the rate of 2 gm. to 50 cc. of diluted (50-50) molasses

No.	Poison	Dead 1 day	Dead 2 days	Dead 4 days	Dead 8 days	Total holes in leaves
1	Sodium arsenite	4	11	13	15	55
2	Zinc arsenite	1	2	5	11	80
3	Lead arsenate	1	2	2	3	225
4	Paris green	1	4	6	12	40
5	Magnesium arsenate	0	1	3	8	100
6	Check	0	0	0	0	300

The following sweet products were used as attractive agents: molasses, corn syrup ("Karo"), cane sugar, honey, lactose and maltose. All of these were consumed when in a moist state. Molasses, corn syrup and cane sugar were the most attractive. When the sweet products, particularly molasses, were placed in large drops on fresh rose leaves the beetles (in most cases) chose the sweet material in preference to the rose leaves. The water content of the sweetened bait is important. Dry or hardened sweet products did not attract the beetles. Several experiments along this line and various observations on the response of the adults to fresh moist baits and to old somewhat hardened baits confirmed the fact that they prefer baits with a high water content.

Various arsenical products and other poisons such as nicotine and sodium cyanide were used as the toxic agent in the baits. Several of the arsenical compounds proved to be the most effective. Nicotine in small quantities in the bait was useless because the adults refused to consume such bait. It is probable that the nicotine can be detected and is distasteful to the adults. Sodium cyanide, in small quantities, was unsatisfactory when mixed with molasses because it decomposes to some extent. A strong odor of hydrocyanic acid gas could be detected on mixing the two products. Freshly made baits containing sodium cyanide placed in tight cages stupefied the adults for a few hours. After the adults recovered some of them consumed the bait and in 5 days 40 per cent were dead.

A number of series of trials were made with various arsenical compounds to determine which was the most satisfactory toxic agent for poisoned baits. Table 4 gives the results of a typical series. In these experiments 15 adults were placed in petri dishes with 3 untreated fresh rose leaves. On one of the leaves a large drop of poisoned bait was placed. Each 24 to 48 hours the old leaves and bait were removed and new fresh leaves and bait were insured. In all of these experiments molasses was used as the sweet attractive agent. It was diluted with 1 part of water to 1 part of molasses. The arsenical compounds were used at the rate of 2 gm. to 50 cc. of diluted molasses. The table shows that sodium arsenite gave the most rapid kill and comparing similar experiments with these, sodium arsenite gave the greatest percentage of kill. This is probably due to the high soluble arsenic content of sodium arsenite. Zinc arsenite and paris green came second in their killing efficiency, while lead arsenate was quite ineffective.

Since sodium arsenite proved to be the best arsenical compound, the question arose as to what strength would be the most satisfactory. Table 5 shows the results of using sodium arsenite at the rate of ⅛, ¼, ½, 1, 2, and 4 gm. to 50 cc. of diluted molasses. The 2 gm. to 50 cc. gave the most rapid kill, yet all of the strengths from ¼ gm. to 4 gm. to 50 cc. killed all of the adults in 10 days. It should also be noted that 4 gm. to 50 cc. killed with less rapidity than 2 gm. to 50 cc. This may be due to the fact that the arsenic content was too great. In other words it could be detected by the adults and probably was distasteful. This experiment and others of a similar nature indicate that too much arsenic in the food makes it less attractive. The above experiments were conducted in a manner similar to the foregoing series shown in table 4.

In connection with the poison-bait investigation we tried to determine the amount of arsenic necessary to kill the adults. The amount consumed was too small to measure accurately; however, we noted the fact that there was an interesting relationship between the length of time the adults feed on the bait and the percentage of kill.

The adults on finding the fresh poison bait submerge their mouth-parts into it and continuously move their mouth-appendages, indicating that they are consuming the bait as rapidly as possible. In lots of 5, each adult was permitted to feed for a definite period of time and then placed in a petri dish with fresh, untreated rose leaves. The time intervals were 1 to 5, 15, 30, 60, 120 and 180 seconds, and 5 adults were permitted to satisfy their own appetites. Table 6 shows the results of these experiments. After 4 or 5 days all of the adults were dead which had fed for 180 seconds or satisfied their appetites.

TABLE 5

Rapidity and extent of kill of 25 adults of *T. canellus* after feeding on poison bait* containing varying amounts of sodium arsenite

No.	Grams per 50 cc. of molasses*	Dead 1 day	Dead 2 days	Dead 3 days	Dead 4 days	Dead 5 days	Dead 10 days
1	0.125	0	0	1	4	8	11
2	0.25	0	2	6	15	21	25
3	0.50	2	6	10	17	22	25
4	1.0	7	12	13	22	24	25
5	2.0	12	22	24	25	25	25
6	4.0	5	10	16	18	22	25
7	check	0	0	0	0	0	0

* Molasses 50 per cent; water 50 per cent.

At the end of 10 days there was a consistent series of results from no dead adults with 1 to 5 seconds of feeding to all dead with 180 seconds of feeding or appetites satisfied. The number of adults in the above experiments was small yet the results indicate that the length of the feeding period or the poison consumed determines the percentage of dead.

After it was determined that sodium arsenite at the rate of 2 gm. to 50 cc. of diluted molasses was an attractive bait and highly toxic several experiments were conducted in the greenhouse, to determine its practical use. Individual uninjured plants were caged with 15 adults and the above poison baits were placed in cages made of cheesecloth. In some of the cages rags or bunches of dried rose leaves were soaked with the bait and placed in the center of the bush suspended on sticks or from the bush itself. In other cages dried rose leaves soaked in bait were scattered on the ground. The above experiments were examined after 5 and 10 days. Where the poison bait was held

in bunches of leaves the smallest amount of injury to the leaves on the bushes appeared. In the experiments where the leaves were scattered on the ground the injury was approximately the same as in the checks. Only a few of the original 15 adults placed on each plant were found at the end of 10 days, consequently the percentage of dead adults could not be determined. Even though the percentage of dead adults was not determined it is assumed that the poison bait had some effect in a few of the experiments, for the amount of injury was considerably reduced and this reduction must have been due to feeding on the poison bait. We know from other experiments that adults will

TABLE 6

Relation of the length of the feeding period on poison baits of 5 adults to the percentage of kill. Sodium arsenite, 2 gm. to 50 cc. of diluted *molasses (molasses 50 per cent, water 50 per cent)*

No.	Feeding period	Dead 1 day	Dead 2 days	Dead 3 days	Dead 4 days	Dead 5 days	Dead 10 days
	seconds						
1	1 to 5	0	0	0	0	0	0
2	15	0	0	1	1	1	1
3	30	2	2	2	2	2	2
4	60	3	3	3	3	3	3
5	120	0	3	3	3	3	4
6	180	0	3	4	5	5	5
7	Appetites satisfied	2	4	4	4	5	5
8	check	0	0	0	0	0	0

not consume a normal amount of foliage for a considerable period, 10 days or more, after they partake of arsenical compounds. They may not be killed by the arsenic but they do not have a normal appetite for rose foliage.

Another experiment was tried in July, 1919, with dry leaves soaked in the poison bait (sodium arsenite 2 gm. plus molasses 25 cc. plus water 25 cc.) and scattered over the ground. These were sprinkled about the base of 18 recently pruned rose-bushes which were enclosed in a tight cheesecloth cage. Two cages were constructed about 36 plants, 18 in each cage. Each plant in the cages possessed 8 to 12 uninjured leaves. Seventy-five adults were placed in each cage and a jar of recently-cut uninjured rose shoots. The uninjured shoots gave the adults a greater amount of food. In 7 days all of the leaves and new buds in each cage were examined for injury. The check plot

showed 98 injured leaves out of 163 on the bushes, and the treated plot showed 117 injured leaves out of 187. The twigs in the jars also showed decided injury in both the check and the treated plots. The above results indicate that dead leaves soaked with poison bait and scattered on the soil have little or no effect on the beetle. The only method of treatment with poison baits which gives promise of being satisfactory is the suspension of the moist poison bait at one or several points in the center of each bush. This involves the development of some kind of a holder for the bait which will keep the bait from dripping on the plants when they are syringed and also prevent it from drying.

Dry poisoned bait has little or no attraction for the beetle. So far we have not found a satisfactory container.

Light

The author made a number of observations at night to determine the behavior of the beetle. Several lights were employed, such as electric light (Mazda lamp), kerosene lamps and bright gasoline lamps ("Quick Light Lantern," manufactured by the Coleman Lamp Co.), and in no case could it be said that the adults were attracted to the light. The light placed near the beetles usually arrested their feeding until they became accustomed to it. A. E. Steine, of Rhode Island, reports that one of the rose growers in his state is using trap lanterns, and he is catching a large number of adults of this species. This control measure should be given a thorough trial.

Beating

In late summer of 1918 the florist decided that he would catch as many as possible of the adults by beating the infested bushes each morning between 7 and 9 o'clock and on cloudy days. As mentioned before many of the adults will suddenly draw up their legs to their body and fall to the ground if they are disturbed when they are crawling on the plant or feeding. The workmen were instructed to place a pan or dish of some description under each bush on the infested benches and tap the canes or the wire support for the bushes. Many of the beetles falling from the bushes landed in the pans and when a considerable number were obtained they were thrown into a fire or dumped into kerosene.

In 1918 the adults were particularly abundant on four benches of Hoosier Beauty roses. During the late summer and fall of 1918 these bushes were beaten almost every day until the adults became exceedingly scarce (1 to 5 per bench). When the adults were abundant the men would obtain 100 or more from each bench. In

1919 these benches were watched for a reappearance of the adults which did so much damage in 1917 and 1918. At no time except during June and July was there any indication of beetle work. Even in June and July the adults were scarce on these benches. During the entire summer and early fall of 1919 the florist kept up the beating of all infested bushes in the various houses. So far this year the author has visited the greenhouse every 15 to 30 days and during February, March, April, May and June, and few if any adults have been found. We fully expected to find a number of adults during June, 1920, but they did not appear.

The almost complete eradication of the beetles at Summit has been very striking. It is probable that the diligent beating method employed has almost eliminated the pest. Probably some other unknown factor such as parasitism may have brought about this eradication, but if this is true we have not discovered it.

Acknowledgments

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Reference

(1) Weigel, C. A., and Chambers, E. L., 1920. The strawberry root-worm injuring roses in greenhouses. *In* Jour. Econ. Ent., v. 13, p. 226-232.

CRANBERRY INVESTIGATIONS

CHARES S. BECKWITH

Introduction

During the year the cranberry substation has carried on three lines of investigation. The plant-food study has been enlarged to include a test of different sources of nitrogen and phosphoric acid as well as the optimum amount of a tentative complete cranberry mixture for Savannah land. The soil-acidity investigation as described in the Annual Report for 1918 has given its second year's records. The more serious insect pest of the year has been studied with the purpose

of finding a more practical control. Soil-moisture investigations had to be discontinued because the state authorities failed to provide funds promptly on July 1 and the time for the study was past before the funds were available.

Plant-Food Investigation

The New Jersey Agricultural Experiment Station has been investigating the use of plant-food for cranberries in a general way since 1913. The preliminary work showed that there were three types of cranberry soil: Savannah, mud and mud underlaid with iron-ore deposits. The Savannah soil was a sand with enough dark silt to give the whole a black appearance; the growers often call it "hard-bottom." Mud, on the other hand, consists of from 10 inches to 20 feet of peat usually over hardpan. Mud sometimes occurs on top of iron-ore deposits and in such cases its composition differs from that on ordinary hardpan.

The plant-food work of the Station between 1913 and 1918 was limited to testing the effect of various plant-foods and the best sources of each ingredient. The results brought out the following six points:

(1) Both nitrogen and phosphoric acid either alone or combined gave good results on Savannah soil.

(2) Sulfate of ammonia alone was an undesirable source of nitrogen.

(3) Applications of phosphoric acid gave good results on mud and mud underlaid with iron deposits.

(4) Nitrogen derived from nitrate of soda gave results easily shown in quickened vine growth during the week following the application, while nitrogen from dried blood did not show its effect for from 3 to 5 weeks after application. The nitrogen in either case had some effect on the crop during the year in which it was applied.

(5) Phosphoric acid derived from acid phosphate was immediately available while phosphoric acid derived from rock phosphate was not available until the year following its application, but when it became available it was as desirable as phosphoric acid from acid phosphate.

(6) Annual applications of 40 pounds of nitrogen to the acre resulted in too much vine growth.

As stated above, these investigations were planned to indicate the kind of plant-food needed on the cranberry bog and the desirable sources of such plant-food. During 1919 studies were started to determine the quantity of the beneficial plant-foods desirable for annual application; as well as to test the more promising new sources of plant-food. The studies were undertaken to determine the following:

(1) The optimum amount of nitrogen which should be applied annually to Savannah soil.

(2) The derivation of needed nitrogen for Savannah soil from a combination of mineral and organic sources.

(3) The optimum amount of phosphoric acid for Savannah, mud and iron-ore bottoms.

(4) The optimum amount of a tentative formula for mixed fertilizer to be applied to Savannah soil. The tentative formula was made up by the Station on a basis of the results of the last six years.

(5) The value of calcium cyanamide as a source of nitrogen for Savannah bottom and the value of barium sulfate on cranberry soil.

1. The Optimum Amount of Nitrogen Which Should be Applied Annually to Savannah Soil

2. The Derivation of Needed Nitrogen for Savannah Soil from a Combination of Mineral and Organic Sources

The object of this set of experiments is twofold; first, to determine the optimum amount of nitrogen which should be applied annually to Savannah soil, and second, to compare the effect of nitrogen derived from mineral sources with that from organic sources.

Former studies conducted by this Station have shown that 40 pounds of nitrogen is undoubtedly too much to apply to an acre of cranberries annually; also, in the experience of one of the growers, 10 pounds had been applied without beneficial results. Obviously, the optimum was somewhere between these amounts, and the Station determined to try 20 pounds and 30 pounds.

The search for the best source of needed nitrogen, from the experience of the Station with a variety of substances, narrowed itself down to nitrate of soda and dried blood. Either of these substances becomes readily available on being applied to cranberry soil, the nitrate of soda almost immediately and the dried blood in two or three weeks. It was noted that when an application of nitrogen was made entirely from nitrate of soda, the vines made a quick start but it was assumed that the plants were unable to maintain a satisfactory rate of growth during the season, and the formation of fruit buds for the following season was reduced. Dried blood in comparison with nitrate of soda started slowly and at the end of a month was most active. This suggested the question whether or not a mixture of nitrogen from the two sources might be desirable and accordingly a test was made, with the results as given in table 1.

This study was made on land as nearly uniform as was available. Our former experience had shown that uniform vine growth did not indicate uniform ability to produce a crop. In order to obtain results as accurate as possible, each treated plot was placed between two check plots, and the crop of the treated plot compared with the average of the checks.

As was expected, plot F-SB-N-2 and plot F-SB-N-8 started quickly with a dark green foliage; F-SB-N-4 and F-SB-N-10 showed quick-

ened vine growth somewhat later, and in about 6 weeks F-SB-N-6 and F-SB-N-12 showed more vine growth than the checks. The results indicate that an application of 210 pounds of sodium nitrate to thin vines on Savannah land will tend to produce a heavy covering of vines and an excellent crop. The mixture of nitrate of soda and dried blood was not as good as pure nitrate of soda within the first year. This investigation should produce some interesting results in the second year.

TABLE 1

Results of nitrogen experiments on Savannah soil.
Variety, Early Black

Plot	Treatment per Acre	Nitrogen	Yield per Acre	Increase over Checks
		lbs.	lbs.	per cent
F-SB-N 1	Nothing		3320	
F-SB-N 2	140 lbs. sodium nitrate	20	4280	37
F-SB-N 3	Nothing		2920	
F-SB-N 4	70 lbs. sodium nitrate; 85 lbs. dried blood	20	4400	48
F-SB-N 5	Nothing		3000	
F-SB-N 6	170 lbs. dried blood	20	3200	-2
F-SB-N 7	Nothing		3560	
F-SB-N 8	210 lbs. sodium nitrate	30	7320	91
F-SB-N 9	Nothing		4100	
F-SB-N 10	105 lbs. sodium nitrate; 127½ lbs. dried blood	30	4660	21
F-SB-N 11	Nothing		3160	
F-SB-N 12	255 lbs. dried blood	30	3920	10
F-SB-N 13	Nothing		3900	

3. The Optimum Amount of Phosphoric Acid for Savannah, Mud and Iron-Ore Bottom

It is recognized that a sufficient amount of phosphoric acid is lacking in most cranberry soils, but the amount that may be applied economically each year is not definitely known. The study here reported was designed to throw light on this problem.

In former investigations conducted by this Station phosphoric acid derived from acid phosphate gave immediate returns; on the other hand, phosphoric acid from rock phosphate gave only moderate increases until after the first year, but when it began to operate in any marked degree its results were quite as good as those from acid phos-

phate. Rock phosphate, because of its alkaline reaction, did not leave an undesirable residue in the soil, and it was the most beneficial of the materials already tested. This was used as the basis of the treatments. As rock phosphate would not become effective until the second year, a treatment was made of an equal amount of phosphoric

TABLE 2

Results of Phosphate Tests.
Variety, Early Black

Plot	Treatment per Acre	P_2O_5	Yield: Savannah SB-F-P Pounds per Acre	Savannah SB-F-P Per cent Gain	Mud SB-F-P Pounds per Acre	Mud SB-F-P Per cent Gain	Iron Ore SB-F-P Pounds per Acre	Iron Ore SB-F-P Per cent Gain
		lbs.						
1	Nothing		2440		7600		2340	
2	125 lbs. acid phosphate	20	2280	-3	9660	18	2000	-10
	75 lbs. phosphate rock	20						
3	Nothing		2240		8700		2080	
4	250 lbs. acid phosphate	40	3720	29	9000	5	3160	90
	150 lbs. phosphate rock	40						
5	Nothing		3520		8060		1160	
6	375 lbs. acid phosphate	60	3200	-4	10140	20	1180	2
	225 lbs. phosphate rock	60						
7	Nothing		3120		8820		960	
8	500 lbs. acid phosphate	80	3580	17	11320	16	1840	30
	300 lbs. phosphate rock	80						
9	Nothing		3000		10900		1880	
10	150 lbs. phosphate rock	40	3000	2	9160	16	2320	0
11	Nothing		2880		10820		2840	
12	150 lbs. soft phosphate rock	40	2840	-2	8340	-9	3820	6
13	Nothing		2920		7640		4400	
14	250 lbs. acid phosphate	40	3440	11	8720	18	4460	37
15	Nothing		3360		7340		2260	

acid derived from acid phosphate. This extra treatment was to furnish phosphoric acid for the first year, the treatment in following years, except on plot 4, to be merely rock phosphate. The treatments and yields are given in table 2.

Series IB-F-P was located on low ground where usually there is sufficient drainage, but during the current year a large amount of rainfall kept the soil saturated and the results are not the best that could be expected.

The test shows that 300 pounds of rock phosphate is not enough to cause damage. Applications of acid phosphate caused increases in yield rather consistently but rock phosphate was not active in the first year. These figures, of course, are based on the one year's crop, and the crop of the second year is expected to show more definite results.

4. The Optimum Amount of a Tentative Formula for Mixed Fertilizer to be Applied to Savannah Soil

The Station felt that it was ready to publish a tentative formula for a complete fertilizer for Savannah land and determine as nearly as possible the amount needed for annual applications. It was made upon the basis of the last 6 years' results and is as follows:

	pounds
Sodium nitrate	75
Dried blood	75
Rock phosphate	300
Sulfate of potash	50

The first year this material was used 300 pounds of acid phosphate was added in order to have phosphate available the year of application.

The results of tests with this mixture are given in table 3.

TABLE 3

Results of tests with a mixed fertilizer on Savannah soil. Variety, Early Black

Plot	Treatment per Acre	Yield per Acre	Increase Over Checks
		lbs.	per cent
SB-F-C-1	Nothing	3800	
SB-F-C-2	264 lbs. mixture; 176 lbs. acid phosphate	4780	20
SB-F-C-3	Nothing	4000	
SB-F-C-4	528 lbs. mixture; 352 lbs. acid phosphate	5180	20
SB-F-C-5	Nothing	4680	
SB-F-C-6	792 lbs. mixture; 528 lbs. acid phosphate	6340	38
SB-F-C-7	Nothing	4500	
SB-F-C-8	1056 lbs. mixture; 704 lbs. acid phosphate	5200	49
SB-F-C-9	Nothing	2860	

Plot SB-F-C-9 proved abnormally poor and on this account plot SB-F-C-8 showed a high percentage of gain, although it actually yielded a smaller crop than plot SB-F-C-6.

That plot SB-F-C-8 was over-fertilized was shown by the excessive vine growth on the plot and the many "runners" that appeared on top of the vines. The crop was somewhat less than on SB-F-C-6 which was in excellent condition. Plots 2 and 4 are expected to give much better yields the second year.

5. The Value of Calcium Cyanamide as a Source of Nitrogen for Savannah Bottom and the Value of Barium Sulfate on Cranberry Soil

Calcium cyanamide was tested as a cranberry fertilizer in 1919. The material used tested 18.16 per cent nitrogen. The treatments were made on Savannah soil on Howe berries, with the results reported in table 4.

TABLE 4

Results of tests with calcium cyanamide on Savannah soil. Variety, Late Howe

Plot	Treatment per Acre	Yield per Acre	Increase Over Checks
		lbs.	per cent
1	Nothing	5860	
2	120 lbs. calcium cyanamide	4900	—17
3	Nothing	5900	
4	120 lbs. calcium cyanamide, 250 lbs. acid phosphate, 220 lbs. sulfate of potash	6000	2
5	Nothing	5900	
6	120 lbs. calcium cyanamide, 2000 lbs. ground limestone	4740	—20
7	Nothing	5900	
8	120 lbs. calcium cyanamide, 250 lbs. acid phosphate, 220 lbs. sulfate of potash, 2000 lbs. ground limestone	6340	6
9	Nothing	6040	

The results indicate that as a source of nitrogen calcium cyanamide gives unsatisfactory results in the first year. This is shown both when it is applied alone and when applied with limestone. The loss was not serious when used in a complete fertilizer but the gain over the checks is small.

6. Test of Barium Phosphate as a Source of Phosphoric Acid

Barium phosphate was suggested as a source of phosphoric aci and was tested during 1919. The treatments and the results ar given in table 5.

These results indicate that barium phosphate has little plant-foo value for cranberries within the first year after its application.

TABLE 5

Results of tests with barium phosphate. Variety, Early Black

Plot	Treatment per Acre	P_2O_5	Yield: Savannah, Pounds per Acre	Savannah, Per cent Gain	Mud, Pounds per Acre	Mud, Per cent Gain	Iron Ore, Pounds per Acre	Iron Ore, Per cent Gain
		lbs.						
1	Nothing		2920		7640		4400	
2	250 lbs. acid phosphate	40	3440	11	8720	18	4460	37
3	Nothing		3360		7340		2260	
4	150 lbs. phosphate rock and 7 per cent barium sulfide	40	3560	8	7840	1	1060	40
5	Nothing		3160		7920		1480	
6	150 lbs. soft phosphate rock and 7 per cent barium sulfide	40	3240	9	7120	—2	2020	20
7	Nothing		2760		6580		2000	
8	150 lbs. barium phosphate	40	2400	—9	6440	—3	2940	—2
9	Nothing		2480		6680		5880	

Conclusions

The experience of the first 6 years of cranberry plant-food studie has shown that general conclusions cannot be based upon the result gained with one year's crop, but the results are valuable in that the give some indication of what to expect in a general way. The fol lowing are the chief points brought out by investigations:

1. Thirty pounds of nitrogen to the acre gave a better yield than 20 pounds per acre in the first year of the application. The vines receiving either amount were left in excellent condition.

2. Applications of a mixture of mineral and organic sources of nitrogen did not give a better crop than nitrate of soda alone during the first year.

3. The optimum amount of phosphoric acid to be applied was at least 80 pounds on Savannah soil, mud bottom and iron-ore bottom.

4. The optimum amount of the tentative mixed fertilizer for Savannah bottom is 800 pounds, together with 500 pounds of acid phosphate in the first year. This amount of fertilizer, when applied to reasonably vigorous vines, helps to establish a strong growth and to increase the crop.

5. Calcium cyanamide is an unsatisfactory source of nitrogen, in the first year.

6. Barium phosphate is an unsatisfactory source of phosphoric acid in the first year.

TABLE 6

The effect of applications of ground limestone on the yield of cranberries Treated once, 1918

Treatment per Acre	Savannah		Mud		Iron Ore	
	Yield per Acre	Increase over Check	Yield per Acre	Increase over Check	Yield per Acre	Increase over Check
	lbs.	per cent	lbs.	per cent	lbs.	per cent
Nothing	4500		5640			
1000 lbs. pulverized non-magnesian limestone	4480	36	4140	—6	9360	—20
1000 lbs. pulverized non-magnesian limestone	3240	—3	3920	—11	11520	—2
Nothing	2000		3200		11720	
2000 lbs. pulverized non-magnesian limestone	1520	—20	3920	9	10800	—8
2000 lbs. pulverized non-magnesian limestone	1200	—37	3960	10	11849	+1
Nothing	1800		3960		11720	
4000 lbs. pulverized non-magnesian limestone	1200	—35	3040	—32	11840	+1
4000 lbs. pulverized non-magnesian limestone	1120	—40	7640	70	9760	—17
Nothing	1920		5000			

Soil-Acidity Investigation

The cranberry soil-acidity investigation is a continuation of the study started in 1918 and described in the report of that year. The object is to learn the optimum soil-acidity index for cranberry soils

and the best method to obtain it. Preliminary work had shown that the soil was too acid and a correct degree of acidity remained to be determined.

The method was to apply ground limestone in various amounts to the soil and record the yield each year. The record for the 1919 crop is given in table 6.

The results from the limed plots are very uneven and indicate that any general effect on the crop is not apparent until after the second year. This may be due to the fact that limestone applications on cranberry bogs are made on the surface and that it is impossible to mix the soil after the treatment is made. For this reason a very slow action takes place.

TABLE 7

The effect of applications of ground limestone on the yield of cranberries treated annually 1918 and 1919

Treatment per Acre	Savannah: Yield per Acre	Savannah: Gain over Check	Mud: Yield per Acre	Mud: Gain over Check	Iron Ore: Yield per Acre	Iron Ore: Gain over Check
	lbs.	per cent	lbs.	per cent	lbs.	per cent
Nothing	2970		4930			
1000 lbs. pulverized non-magnesian limestone	2350	—8	5480	—9	9360	—15
1000 lbs. pulverized magnesian limestone	2460	—4	5360	—11	10430	—4
Nothing	2130		7130		10830	
2000 lbs. pulverized non-magnesian limestone	2320	+5	4185	—50	9680	—12
2000 lbs. pulverized magnesian limestone	3020	+39	6040	—25	9650	—12
Nothing	2240		9280		10830	
4000 lbs. pulverized non-magnesian limestone	2240	—10	3465	—50	9020	—18
4000 lbs. pulverized magnesian limestone	3690	+50	4455	—36	10800	0
Nothing	2650		4600			

The spring of 1920 showed all of the plots in good condition and there was some apparent difference in the vine growth between the untreated and treated plots. This may make some more definite conclusions possible in the 1920 crop.

Cranberry Insects

Cranberry Blossom-Worm

The cranberry blossom worm and its work has been described by I. B. Scammell in Farmer's Bulletin 860, "Cranberry Insects and Suggestions for Solving Them." The pest has never been known to do damage on the bogs before this year, but a number of causes have led to a serious outbreak. Although present on most New Jersey bogs, the pest is controlled by the reflow given to control fireworms. The newer methods for controlling fireworms have been so thorough that the reflow has not been necessary every year and many growers have fallen into a habit of not reflowing more than one year in three. This method allows the blossom worm to increase and become a pest of first importance during the third year.

During 1919 a large part of the crop on the Savannah land at Whitesbog was cut out by the blossom worm. The spring of 1920 found a fairly uniform infestation on all the bogs when a reflow was designed especially to meet this pest.

The presence of the worms was determined about the time the earliest buds began to show color and the reflow was put on as soon thereafter as possible. The length of time the water was on the bog was recorded and the results are shown in figure 1.

It is obvious from these data that a complete flooding for 24 hours will control the blossom worm.

Cranberry Girdler

The cranberry girdler often attacks the higher and well drained portions of bogs leaving the lower portions almost untouched. As the insect is the most destructive pest that attacks the vines and it is often out of reach of ordinary flooding operations, an effective insecticide is especially desirable.

In Japanese beetle control work sodium cyanide was used effectively to kill the grubs when they were within a few inches of the surface, and this seemed a likely insecticide for the girdler. The material is applied in a weak solution, its killing power coming after 3 days when the solution ordinarily dries out, giving off cyanide gas.

In the method of control we met with some difficulties. In containers used in a solution of 1 ounce of sodium cyanide to 25 gallons of water and applied at the rate of 1 gallon to the square foot, the material killed all the girdlers. In the field, however, a mat of dead leaves on the surface prevented a uniform wetting of the ground surface, and the application followed the course the rain water had made, running off at one point. An attempt to stir the leaves with a

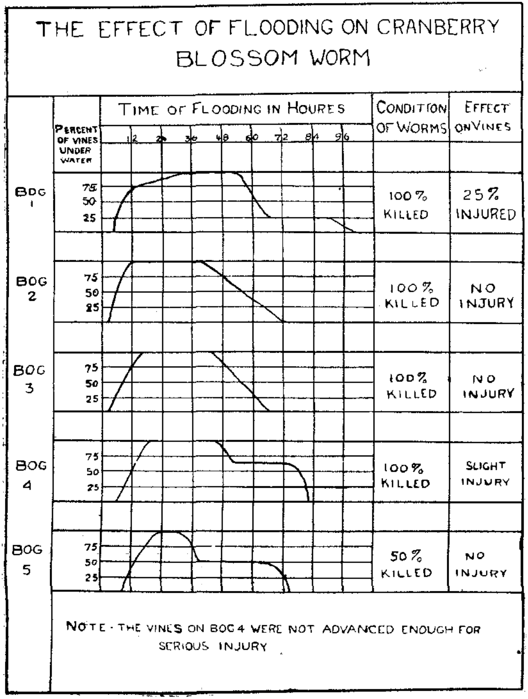

FIG. 1. DIAGRAMS SHOWING THE EFFECT OF FLOODING ON THE CRANBERRY BLOSSOM WORM

water jet from a force pump failed to wet the ground surface properly and the result was a "no-kill."

The work will be continued this year both with sodium cyanide and with other promising insecticides and new tools. It is possible that a suitable method may be designed for this pest.

Visit to the Cape Cod Cranberry Section

During the autumn, the writer together with Dr. Headlee visited the Massachusetts Cranberry Station. As the guests of Dr. Franklin, they were able to see types of bogs which showed us the more interesting features of cranberry-growing on Cape Cod. The trip was a great help in planning new work in the New Jersey cranberry-growing section.

Acknowledgment

The writer wishes to take this opportunity to express his sense of obligation to the Research Committee of the American Cranberry Growers' Association, F. S. Chambers, Thomas Durell, H. B. Scammell and A. E. Freeman; and to Dr. Jacob G. Lipman, Director, and Dr. Thomas J. Headlee, Entomologist, of the New Jersey Agricultural Experiment Stations. The work reported here has been done by the writer in close cooperation with the above-mentioned men.

REPORT OF MOSQUITO-CONTROL WORK

Thomas J. Headlee
Mitchell Carroll

I. INTRODUCTION

During the fiscal year ending June 30, 1920, the entomologist as executive officer in charge of mosquito work for the state, and his staff have given their attention to: (1) ditching as many acres of salt marsh as available funds would permit under authority of Chapter 134, Laws of 1906; (2) the study or survey of salt marshes with a view to later work; (3) a general oversight and inspection of the work of the county mosquito extermination commissions; (4) making surveys and furnishing plans and estimates requested by boards of health and other organizations and individuals.

II. EXPERIMENT STATION CONTROL WORK

A. Upland Work

Mosquito-Control Work for the Protection of the Camden and Gloucester Shipyards

In the spring of 1918 the New York Shipbuilding Company, the Camden Forge, the New Jersey and Pennsylvania Shipyards and the United States Emergency Fleet Corporation subscribed a fund of $10,500 to be carried on in South Camden and Gloucester. The work was carried on under the supervision of this department, George H. Cushing, formerly of the Ocean County Mosquito Extermination Commission, being placed in charge as temporary assistant. The total cost of the three months' campaign under Mr. Cushing's efficient direction was $3,616.85. The balance of the fund subscribed was returned to the contributors.

The success of the 1918 work was apparent to all the interested parties. It seemed to those interested, also, that the mosquito pest should not be allowed to prove an obstacle to the completion of the government's shipbuilding program during the season of 1919. Accordingly after a conference between representatives of the United States Shipping Board, the Camden and Gloucester shipyards and the entomologist, it was agreed to continue the mosquito-control work

for the summer of 1919. This department, as before, furnished the expert supervision, and the necessary funds were subscribed as for the preceding season's work. Mr. Cushing not being available, John L. Bennett was first placed in charge. Mr. Bennett soon resigned. Hugh E. Thomson, formerly an inspector for the Union County Mosquito Extermination Commission, was then appointed temporary assistant in charge of the work.

Mr. Thomson was able to give the shipbuilding companies a large measure of protection as is evidenced by testimonials from representatives of these corporations on file in this office. Mr. Thomson's report follows.

I. Aim and Organization of Work

The problem to be handled during the summer of 1919 was much the same as last year, namely, the protection from the mosquito pest of the yards of the New York Shipbuilding Corporation, the yards of the Pusey and Jones Company, Yorkship Village and Norweg Village. In order that the proper amount of money and material be available for this work, the Emergency Fleet Corporation authorized the expenditure of $5,000 through the New York Shipbuilding Corporation. The Pusey and Jones Company did not subscribe a definite sum, but by order of the Emergency Fleet Corporation a blanket order covering the hiring of six laborers for this work was put through. The direction and control of the work was to be under the New Jersey State Agricultural Experiment Station.

Taking into consideration last year's work, the amount of money available, and the work to be done, it was decided to employ 4 inspectors, 1 foreman and 8 laborers in addition to the 6 laborers authorized by the Pusey and Jones Company. Toward the end of August slight reductions were made in the force as a result of better conditions and the need of decreasing the expense somewhat.

II. Area to be Covered

In order to protect the points mentioned above it was necessary to maintain under observation that area bounded on the west by the Delaware River, on the north by Kaighn Ave. in South Camden, on the south by Big Timber Creek and on the east by a line parallel with and about 2½ to 3 miles inland from the Delaware River. This area included in whole or in part the following towns and boroughs: South Camden, Gloucester, Woodlynne, Collingswood, Westmont, Oaklynne, Audubon, Mt. Ephraim, Haddon Heights, and Barrington.

III. Breeding Places

The streams in the vicinity of the shipyards are subject to tidal action, and the many acres of low-lying ground along the edges of these creeks were subject to a continual flooding at high tide. It was hoped that this tidal action would be strong enough to wash out any breeding, and as a result of the heavy storms with their consequent high tides this was so.

Outside of the tidal marshes there were two classes of breeding places, natural and artificial.

There are many natural breeding places to be found in this area, such as swamps, pools and slow streams. A total of 178 such places that were of a permanent character were located and mapped out. Of course, after a heavy rain such as that in July the number of natural breeding places was nearly trebled.

But some of the heaviest breeding found during the summer took place in the artificial breeding places, such as cellars, fire barrels and sewage-disposal plants. At the beginning of the summer Yorkship village was uncompleted and the grading was in such shape that the cellars of the houses became filled with water. There are approximately 1,700 houses in this village. The problem of getting at these cellars was complicated by the fact that as the houses were finished they were locked and as the master-key system was not working, it was necessary to get individual keys for each house.

Fire barrels are used for fire protection at both the shipyards and the model village of the Pusey and Jones Company. There are approximately 450 fire barrels in these three places.

In the area are 6 sewage-disposal plants located at the following points—Collingswood, Woodlynne, Oaklynne, Haddon Heights, Audubon and Yorkship Village.

IV. Plan of Work

The area to be kept under control was divided into districts, and each inspector assigned to one. Inspectors were required to cover breeding places in their districts once every 10 days. Report blanks were provided and the findings of each day reported. When the inspector's district had been completely covered, his reports were consulted and if the amount of breeding justified it, the oil wagon was turned over to him for as long as necessary to cover the breeding found. In this way inspectors were held responsible for breeding within their districts. The only exception to this was in the case of Yorkship village where work was of such importance and extent that it must be quickly taken care of. When it became necessary to treat the cellars here, the whole organization was practically concentrated on the work until it was done.

Drainage, filling, cleaning or such other elimination work as could be done was started in the immediate vicinity of the shipyards and gradually extended out. As a general plan the force other than the 6 laborers from the Pusey and Jones Company was kept at work in the northern part of the controlled area about the New York Shipyard and Yorkship village. The gang at the New York Shipyard was under the foreman hired for that purpose. The men from the Pusey and Jones Company were placed under a competent inspector whose district was small enough for him to give them proper attention.

V. Actual Elimination Work Done

The following list will show the actual elimination work done. It will be noted that in cases where pools and swamps overgrown with cat-tails, etc., could not be drained or otherwise eliminated, the growth was cut so that the places might be effectively oiled.

Four pools on the Camden Ash Dump. The cat-tails in these pools were cut twice during the summer. The city is gradually filling them in with ash and refuse.

Drainage Ditch extending from the Chocolate Caramel Company in South Camden through swampy ground south to the inlet from the Delaware River touching the Reading Railroad. The ditch was deepened and widened, and the adjacent cat-tail swamps ditched into it. It was necessary to do some cutting, as the ground is low and affected by tides. The part cut was kept oiled.

Swampy area on Market Street in Gloucester, excavated by the Pennsylvania Railroad. The existing system of ditches was deepened and others added to it. There were one or two deep pools which it was impossible to get dry. In these the growth was cut and oiling resorted to.

Two swamps in "V" formed by the junction of the New Jersey and Seashore Railroad with the steam line just north of the South Camden depot. These two swamps are connected by inlets with a sewer, but as the sewer is affected by the tide no proper drainage takes place. It would be a simple matter for the city of Camden to install traps in these inlets. The cat-tails were cut, and the ditches cleaned and deepened in an effort to get some of the water to run off.

Swamp on Mt. Ephraim Pike at northern end of Yorkship Village. This swamp had been drained by a wooden culvert which was too high. This was eliminated and a deeper open ditch substituted. The stream running into this swamp was also cleaned and straightened.

Swamp between 6th and 7th Streets on Jersey Avenue in Gloucester. This swamp was first cut as it was overgrown with cat-tails and it seemed impossible to drain it. Later it was found possible to drain the whole thing by opening up a deeply buried sewer inlet. A system of ditches was put in and except for the main ditch this large swamp was completely dried.

Three swamps on Clay Street near Cypress Avenue, South Camden. The cat-tails were cut, drainage ditches opened and the culvert under the road cleaned.

Haddon Heights Lake. This lake has such a small supply of water that there is no overflow in dry weather and it tends to stagnate. The cat-tails in the eastern end were cut, and the ditches leading into it cleaned.

Stream from Haddon Heights Sewage Disposal Plant to King's Highway. This stream carries away the water from the sewage beds and in passing through swampy and low ground it formed sewage-charged breeding places. The whole stream was cleaned and deepened, and where necessary, straightened. The pools and swamps adjacent to it were ditched to the stream.

Pool on Decatur Avenue at Merchant Street in Collingswood. This pool was partly filled in and then the remaining water ditched off.

Ditch and swamp between Oakland and Beloit Streets east of Nicholson Road. The ditch was cleaned and deepened, thus draining the swamp.

Old lake north of Nicholson Road at Beloit Avenue. The lake had been drained but the outlet and drainage ditches were badly stopped up. These were cleaned with a resulting great decrease in the amount of stagnant water.

Swamp east of Camden Forge Company. This swamp was cut in order to make oiling effective.

Large swampy meadow at the Pusey and Jones Company yards. The main ditch running through this meadow (about 4,500 feet) was first cleaned and deepened. A cat-tail swamp about 300 yards south of Charles Street was drained by ditch into another cat-tail swamp in the northeast corner of the meadow. This second swamp had been drained by a tile pipe into the main ditch, but the tile was laid too high to be of very much use. For a distance of 200 yards it was taken up and relaid at a lower level. The meadow is practically cut into three sections by railroad sidings. The northeast section was originally drained by a 16-inch iron pipe under the railroad siding, but when the siding was double-tracked the pipe was not extended, and the opening filled over. This pipe was taken out, cleaned and replaced with additional length sufficient to reach under the double-track embankment. It was then found necessary to clean the remainder of the pipe as far as its junction with main ditch. Along the railroad siding running through the meadow into the property of the Hinde and Sauche Paper Company, there are two other swamps that were ditched and drained into the sewer. In the rear of the Pusey and Jones Company main office was a large pool that was completely drained. Part of this has since been filled in by the Public Service Corporation. In addition to this work about 2,000 feet of piping previously installed for drainage was taken up, cleaned and replaced.

Two swamps on Jersey Avenue in Gloucester near 5th Street. These two swamps were cut for effective oiling, it being impossible to drain them.

In the neighborhood of 6th and Jersey Avenue, three sewage drains were cleaned and deepened, and in one case a collecting pool dug.

VI. Oiling and Larvicide Treatment

As breeding places were reported, the oil gang was turned over to the inspector in whose district the breeding was found. It would be impossible to say definitely how many breeding places were oiled, as numberless temporary pools were treated after wet weather. Except during wet weather one vehicle was kept busy oiling practically all the time, and following the wet period in July both a truck and a wagon were kept busy for one week. In this way 34 barrels of oil were used during the summer.

TABLE 1

Results of Night Collections in Camden and Vicinity

Date	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
June 25	0	0	3	0	0	....
July 2	....	....	0	0	0	....
July 9	0	0	0	0	3	....
August 2	2	1	4	3	3	3
August 11	1	2	2	2	3	4
August 16	2	0	5	4	5	3
August 30	1	2	3	2	2	2
September 5 ..	0	0	0	1	....	....

Station 1—North gate of the New York Shipbuilding Corporation.
Station 2—South gate of the New York Shipbuilding Corporation.
Station 3—Pusey and Jones Company Shipyard.
Station 4—Norweg village.
Station 5—Yorkship village.
Station 6—Gloucester.

Larvicide furnished by the West Disinfecting Company, and of the same composition as that used in Panama, was used for fire-barrels in some cases and for the cellars in Yorkship village. As soon as breeding started in this village a large force was put on the job of spraying the larvicide in the cellars. The village was completely gone over three times during the summer, and isolated sections taken care of oftener. A total of 1,955 cellars were treated.

Also all the catch-basins in Yorkship village, South Camden and Gloucester were oiled twice.

A total of 451 fire-barrels were kept free from breeding, both salt and larvicide being used for this purpose. In all, seven drums of larvicide were used in the treatment of cellars and fire-barrels.

VII. Effectiveness of the Work

Taking into consideration the ideal mosquito-breeding weather of the summer, the work was effective. Until July 15 the mosquito protection was practically 100 per cent perfect. About this time there were 15 days of rain, and some breeding got started which it was impossible to control in time to prevent the appearance of some of the *pipiens*, or house mosquito. These came from the cellars of Yorkship village which presented a particularly hard problem at this time. The night collections for this time and the early part of August show the presence of this mosquito, but their numbers gradually decreased until on September 5 but one specimen was taken with collections made at 4 stations. A summary of the night collections made is given in table 1.

B. Salt-Marsh Ditching

On June 17, 1919, a contract for cutting 60,000 linear feet of ditches 10 inches wide and 15 inches deep, or their equivalent, and 14,074 linear feet of ditches 10 inches wide and 30 inches deep, or their equivalent, on the salt-marsh on Island Beach, south of Seaside Park in Berkeley Township, Ocean County, was let to Eaton, Brown and Simpson, Inc. The cost of this ditching was $.0297 per lineal foot, or $2200 for the whole contract.

Work in this area started July 10, 1919. The contractors were held up, however, by a most unusual series of storms and high tides. Consequently, the ditching did not proceed rapidly enough to prevent the emergence during August of enormous broods of *sollicitans* and *sylvestris* from the salt marsh and semi-brackish or fresh swamps immediately south of Seaside Park. Seaside Park, Berkeley and Seaside Heights suffered severely from these broods.

The ditching under this contract was completed about the middle of September.

Another contract was let to Eaton, Brown and Simpson, Inc., on September 10, 1919, for $6,000 for the cutting of 40,000 linear feet of ditches 10 inches wide and 15 inches deep, or their equivalent, and 26,000 linear feet of ditches 10 inches wide and 30 inches deep, or their equivalent, on Island Beach in Berkeley and Lacey townships, Ocean County, 68,250 linear feet of ditches 10 inches wide and 30 inches deep, or their equivalent, on Upper Township, and 68,250 linear feet of ditches 10 inches wide and 30 inches deep, or their equivalent, in Middle Township, Cape May County. The unit cost of this ditching was $.033 per lineal foot for the Island Beach Ditching, and $.028 per lineal foot for the Cape May Ditching. The higher unit

cost of the Island Beach trenching is due to the fact that very little of it can be done by machine.

The ditching under the contract of September 10 was begun about October 1, 1919, and completed about January 10, 1920.

In Upper Township the ditching was begun at the point reached in the previous year's work. The salt marsh drained is bounded on the south by the upland, on the north by the Tuckahoe River and on the east and west by Willis Thoroughfare. This block of drainage, though small, is another step in the elimination of breeding on the extensive marshes south of the Tuckahoe River. The Atlantic County Mosquito Extermination Commission is draining the meadows on the north side. The completion of the drainage of the Tuckahoe River marshes will eliminate the largest breeding area from which broods now escape to infest Atlantic and Ocean cities.

The 68,250 linear feet of ditching allotted to Middle Township was used to drain a narrow strip of salt marsh adjacent to the upland, extending from the Wildwood Meadow Boulevard on the south to the Anglesea Railroad on the north. The Cape May County Mosquito Extermination Commission had previously ditched the meadows south of the Wildwood Boulevard and has just completed, by contract with H. I. Eaton, 100,000 linear feet of 10 by 30-inch ditching in the area of salt marsh lying north of the Anglesea Railroad. This drainage in Middle Township, when completed, is designed to protect Holly Beach, Wildwood, Anglesea, Avalon, Stone Harbor and Sea Isle City from salt-marsh mosquitoes breeding on the Atlantic coast meadows. But these resorts can scarcely, of course, be entirely free from the salt-marsh mosquito pest until more of the Cape May County Delaware Bay marshes have been ditched.

With the 66,000 linear feet of standard ditching allowed by the contract of September 10 for Island Beach, the drainage of the salt marshes and brackish swamps on this beach has been completed for about 3½ miles south of Seaside Park. But there are in this area numerous small fresh-water swamps, wild cranberry bogs, cat-tail, poison-ivy, and cedar swamps, etc., which the Experiment Station has no authority to drain under Chapter 134, Laws of 1906. These small areas, large enough in the aggregate to throw off considerable broods of *sylvestris*, *pipiens*, and other fresh-water forms, will have to be drained by the Ocean County Mosquito Extermination Commission before the resorts on this beach can reap much benefit from the drainage installed by the Station.

There are few areas in the state as difficult to drain as the brackish swamps and marshes on Island Beach between Seaside Park and Barnegat Inlet. The salt-marsh sod is from 2 to 15 inches deep, and is underlaid by sand. So it is possible to use only the shallowest ditches for mosquito drainage. Outlets into the bay are continually being obstructed by sand and floating eel-grass. Moreover, since the only outlet for the 20 miles of bay to the northward is the narrow

Barnegat Inlet, the diurnal fluctuation of the tide cannot be depended on to empty the ditches. Easterly or southerly winds back the water up in the bay, where it stays until the winds shift to another quarter.

To meet the ditch-outlet problem of Upper Barnegat Bay a device suggested by the entomologist and installed as an experiment with the cooperation of the Ocean County Commission is described elsewhere in this report.

C. Plans and Surveys

The Drainage of Dismal Swamp in Middlesex County

At the request of the board of health of Metuchen, Middlesex County, Charles S. Beckwith was assigned to make a survey of the marshy area known as Dismal Swamp, adjoining the Borough of Metuchen, to determine if mosquito breeding in this area could be eliminated at a reasonable cost. After a careful survey Mr. Beckwith submitted the following plan and estimates for the drainage of the swamp.

Drainage Plans for Dismal Swamp for the Purpose of Eliminating Serious Mosquito Breeding

CHARLES S. BECKWITH

Introduction

The drainage basin of Dismal Swamp includes about 6,500 acres, of which about 600 acres may be designated as real swamp land. The drainage channel is known as Dismal Brook and extends from near Metuchen through the low-lying land to South Plainfield and thence through higher land to New Market. The important species of mosquito breeding in this area, is the fresh-water swamp mosquito which studies within the last five or six years have shown to have an extreme migratorial range of 10 miles under conditions of extraordinary abundance. These studies have likewise shown that, unless the breeding is very concentrated and the number of mosquitoes emerging very large, long migrations do not take place. They also indicate that this species of mosquito tends to move from the place of breeding toward the nearest center of population.

The discussion of the drainage of this low-lying area known as Dismal Swamp, is based entirely on the elimination of the mosquito pest breeding therein, and has nothing whatever to do with agricultural improvement.

Drainage Plans

For the purpose of discussion the drainage of the Dismal Swamp has been divided into three parts. The first part has been designated as section I and lies between Metuchen and the Wood Brook Farms. The second, designated as section II, includes the Wood Brook Farms property. The third has been designated as section III and extends from the border of the Wood Brook Farms property to the Spicer dam at South Plainfield.

Section I

In section I the swamp comprises about 185 acres of wet land. Dismal ;rook, the natural outlet of this section, runs from a culvert under the Lehigh alley Railroad near the Public Service Power Plant to a large culvert under ıe Port Reading Railroad and thence north to the Wood Brook Farms ›undary. The southerly section comprising about 1500 feet is badly blocked ıd it is with considerable difficulty that the course of the stream can be fol- ›wed. As it approaches the Port Reading culvert it has a definite stream bed, ıd some care has been taken of it.

The importance of this stream can more readily be realized when one remem- ›rs that it carries the storm run-off of about nine-tenths of the inhabited por- on of Metuchen. The blockage of this stream prevents the escape of surface ater both from Metuchen and from the swamp proper in section I, thus :eating and maintaining serious breeding places for mosquitoes. It is thought ıat the water accumulation due to this blockage is responsible for the breeding ' most of the fresh-water swamp mosquitoes that have troubled Metuchen dur- ıg recent years.

A profile of the water surface through this section shows that in the 5000 et of brook under consideration there is between 7 and 8 feet of grade, indi- ıting clearly enough that if the blockages were removed the surface water in :etuchen and the surface water of the swamp proper in section I would readily › drawn away. About 5000 feet of the Dismal Brook channel lying within sec- on I should be recut and cleaned. The channel should be made 4 feet deep ıd 6 feet wide at the bottom, with the sides at an angle of rest, and should be ıt to grade.

Branch streams or ditches leading into the brook at various points along its ›urse would have to be opened, as would also much of the present drainage ıannels in the Borough of Metuchen itself.

Special Difficulties to be Overcome. The first difficulty is the present level ' the pond at the Public Service power plant. It is true that the ditch ınning from Metuchen along the northeast side of the Lehigh Valley Railroad acks is not seriously affected by this pond; nor is the drainage of that por- on of Metuchen, which depends upon this said ditch, seriously affected. The tch running from Metuchen along the southwest side of the Lehigh Valley ailroad tracks and all the territory in Metuchen which depends upon this tch for its drainage is very seriously affected by the present level of the ublic Service pond. It is suggested that the Public Service pond be bypassed ; the ditch lying on the southwest side of the Lehigh Valley Railroad and also : *the channel of Dismal Brook itself. Of course, the Public Service Cor-* ›ration, if they desire to do so, can meet the situation and also maintain e necessary water for their work by lowering the bottom of their pond to a ›int where the drainage channel on the southwest side of the Lehigh Valley ailroad can still empty its water through their reservoir and not hold back .e drainage of that part of Metuchen which depends upon it.

The second difficulty is found at the culvert under the Port Reading Rail- ad. Here we find a flag-stone bottom in the culvert and a couple of oil pipe ıes crossing the stream at a low level just above the culvert. If the Dismal rook is recut, as above suggested, there is little doubt but that plenty of space r the passageway of water underneath these pipe lines will be made, and the moval of a certain width of this flag-stone bottom of the culvert under the ›rt Reading Railroad will become a necessity.

Estimated cost of operations. Recutting 5000 feet of main drain 4 feet deep, feet wide at the bottom to grade will amount to $750; cutting 9000 feet of bdrains will amount to $900; tools and boots will amount to about $150. ıus we have a total of estimated cost for the operations necessary of $1,800. his does not include any drainage east of the Lehigh Valley Railroad nor uth of Durham Street.

Section II

Fortunately, the Wood Brook Farms area, which includes most of the low land in section II, has already been drained for agricultural purposes and the drainage seems to be such as to eliminate all extensive mosquito breeding.

Along the line of the Lehigh Valley Railroad in this section the maintenance of ditches has been very inadequate and they have been used as dumping places for refuse consisting of bottles, cans, etc. The water thus held back makes mosquito-breeding places and the Lehigh Valley Railroad should be expected to reopen these ditches.

Section III

Section III comprises about 225 acres of wet woodland swamp, a large portion of which is a potential mosquito-breeding place. The drainage of this area is handicapped, or almost entirely prevented, by a dam constructed on the property of the Spicer Manufacturing Company at South Plainfield.

We have not been able to find what water rights this company has, but are thoroughly convinced that no complete mosquito drainage is possible so long as the dam remains in its present position.

If the dam were removed the needed work for mosquito control would be the cleaning and recutting of the main stream together with the cutting of 10,000 feet of sub-main ditch. With all this work done the fresh-water swamp mosquito would not breed in section III of the Dismal Swamp.

Estimated Cost of Operations. It is estimated that the recutting of the main drainage channel in section III would involve about 4500 feet and cost about $675. It is further estimated that 10,000 feet of sub-main drainage would have to be installed at a cost of about $1,000. Tools would probably run to $200, making the total cost of the operation, provided the dam can be removed without expense to the project, $1,875.

Conclusion

In conclusion it should be said that the carrying out of the work on section I as outlined should result in freeing Metuchen from most of the fresh-water swamp mosquitoes, which have been coming to her from this swampy area, and should at the same time afford a fairly adequate outlet for her surface water. It should be remembered, however, that the choked-up ditches along the Lehigh Valley Railroad in section II should be cleaned out, or a certain amount of breeding may occur there, which may reach Metuchen. The expense of cleaning these Lehigh Valley ditches should be entirely chargeable to the Lehigh Valley Railroad.

The removal of the dam at the Spicer Manufacturing Company in South Plainfield, the lowering of the main channel and the cutting of sub-main ditches should practically eliminate all trouble by mosquitoes which breed in section III and fly to adjacent towns.

In view of the fact that for an expenditure of around $1,800 the Borough of Metuchen can free itself of the mosquitoes which ordinarily breed over two-thirds of the entire Dismal Swamp and that the area thus freed is that portion of the swamp which lies next to Metuchen and at the same time obtain an outlet for her surface water, it would seem wise for the borough to undertake a movement to do the ditching work recommended in section I and to induce the Lehigh Valley Railroad to clean out its ditches in section II.

The Drainage of Fishing Creek Meadow in Cape May County

The Cape May County Mosquito Extermination Commission having called on the entomologist for advice in regard to the drainage of Fishing Creek Meadow, Charles S. Beckwith was directed to make a survey and draw up plans with estimates for a proper outlet. Mr. Beckwith's report follows.

Improved Outlet for Fishing Creek

CHARLES S. BECKWITH

Geography

Fishing Creek flows into Delaware Bay at a point 7½ miles from Cape May. The drainage area included in the creek basin is 5200 acres in extent, 910 acres of which is either tidal marsh, fresh-water swamp or water surface. The highest point in the drainage area is 27 feet above mean tide. The height of the tidal marsh in this section is approximately 2.6 above mean tide at Sandy Hook, approximately 2.75 above local mean tide, or 4.95 above local mean low tide.

The present natural outlet does not drain the marsh because it fills with sand on high tides and it is only after the water from the inside has made an outlet that the creek will flow at all. This means that there will always be a surplus of water left in the creek and at the present time, February 14, 1920, this "surplus" covers the meadow 6 inches deep.

The shore line along Delaware Bay is a series of small sand hills together with a sand beach and, further out, mud flats. The flats are approximately at mean low tide. The tops of the sand hills are slightly higher than the highest storm tides; their formation probably has been caused by the higher waves on the storm tides depositing sand there. The marsh level inside the hills is approximately 5 feet higher than the mud flats outside.

The Profile

The profile of Fishing Creek marsh included with this report was made while the marsh was frozen. The writer operated a transit as a level, Mr. Schellenger held the rod and Mr. Ewing and Mr. Orlie chained the distances. The bottom of the creek was extremely soft and readings of the stream profile may be misleading, but they were taken to the top of the mud. The meadow level was taken directly on the sod surface.

The eastern end of the stream (source) is in large lily ponds in which no trace of the stream itself could be found. The extreme eastern portion is a wooded fresh-water swamp somewhat similar to a cedar swamp.

The profile shows the meadow surface gradually to sink as it leaves the bay shore, the extreme point being 6 inches lower than the meadow at the bay shore. The present outlet has built up a considerable delta of sand which extends from 100 to 300 feet farther out than the line of the sand beach. The outlet itself is a "U" shaped cut between the hills and the creek has a sharp bank for about 150 feet.

Improvement

There are two possible methods of improvement in the case of Fishing Creek marsh—one by means of jetties and the other by a flume with tide-gates.

Jetties

The first is to hold the present outlet open with retaining walls built in such a fashion as to allow the tide to come in and go out unrestricted. With such a wall the mouth of the creek must be widened, deepened and maintained in this fashion in order that the enormous tidal marsh may be nearly covered and then drained twice every day. The expense of such operation has not been estimated.

Flume with Tide-Gates

The second method is to install a flume through the sand hills so constructed with a tide-gate that the water will pass out freely at low tide and will be closed on high tide. The flume must be large enough to carry out the heaviest precipitation before it has had time to breed mosquitoes. As the tide-gate prevents the tide from coming on the meadow, it is obvious that no allowance must be made for tidal run-off. It must be remembered that a flume built too large will not keep itself free of sand, so that it is impossible to make a large safety allowance in estimating the size of the opening. A flume 6 feet wide and 4 feet high would give 24 square feet, or one square foot to every 200 acres. This is a rather small outlet but when we consider the evenness of the rainfall and the lack of great fall to the creek bed, we feel it is ample to drain it properly.

Special Requirements of the Location. The gate should be hung in a well on the marsh side of the flume so that the debris on the bay will not interfere with the proper working of the gate. As the flume is to go under heavy sand hills, it must be quite strong in construction, the bay end is exposed to wave action and should be easily replaced if broken.

The flume may be made of wood throughout or it may be made of reinforced concrete with a wooden gate. The concrete gives added strength to the flume but the wood is much more easily replaced than concrete. A possible solution is to construct all except the bayside 50 feet of reinforced concrete and then put in the end with wood. This would give the advantages of both types of construction. We have included the specifications of each type of flume together with this report and the joint between them can be easily made.

The cost of the improvement would be in the neighborhood of $3,500.

Specifications for Wooden Flume. 1. The flume shall have an inside measurement of 6 x 4 feet and shall be built of 3-inch tongue-and-grooved short-leaf pine, free from knots or serious blemish; it shall be not shorter than 200 feet and shall extend from the gate well on the eastern side of the sand hills through under the sand-hill. This box shall be stiffened with a 4 x 5-inch rib bolted at each corner with a ½-inch bolt properly washered and drawn up with a satisfactory nut. These ribs shall be placed round the outside of the box fitting it closely at distances of 30 inches apart. The planking shall be firmly spiked to these ribs with 6-inch galvanized spikes.

2. The gate well shall have an inside measurement of 6 by 10 feet by 10 feet deep, the creek side shall consist of 3 by 10-inch short-leaf pine sheet-piling not less than 16 feet long driven until the top is not more than 11 feet above mean low tide as determined by the inspector. The tops of the piling shall be even and bound together by running a 3 by 8-inch stringer along the outside and inside surfaces. Each pile shall be bound to this stringer by a ½-inch bolt which shall be furnished with a large washer and suitable nut.

Additional stringers of similar dimensions shall be bolted flush with the inside edge of the opening made for the gate.

The floor of the well shall be a continuation of the floor of the flume together with additional space on each side to make up a floor surface 10 by 6 inches; each side-wall of the well shall be made of material similar to the floor.

The western end of the gate well shall extend from the floor up 10 feet; it shall be made tight with the flume openings.

3. The culverts shall be laid on a frame made between two round piles set every 10 feet along the course laid out for the flume. The piles shall have 10-inch butts and be so set that they shall fit snugly against the sides of the flume. The frame shall consist of a 4 by 5-inch stringer below the bottom and across the top of the box.

4. The flume and gate-well shall be of good workmanship and of water-tight construction. The former shall have a grade of 3 inches in 100 feet.

5. The gate-box shall be furnished with a 7 by 5-foot gate made of tongued-and-grooved short-leaf pine. It shall be composed of two layers; the inside one being 3 inches thick and 7 feet long and the outside one being 2 inches thick and 5 feet long. The gate shall be hung in the gate-well over the opening with a pair of suitable link hinges so that it readily opens with a falling tide and readily closes with a rising tide. The gate and the gate frame must be of the best workmanship so that it closes with an absolutely tight fit.

6. The sand shall be carefully packed about the box and flume after the construction is complete. Wing walls on the front and rear of the construction may be required, but at an additional cost subject to plans made after the culvert is in place.

Specifications for Concrete Flume and Gate-Well. The following specifications are given to supplement the plans shown accompanying them:

Concrete. The concrete shall be made up of one part of Portland cement to 2 parts sand and carefully mixed.

Foundation. The foundation of the flume shall consist of round piling with 10-inch butts set in two rows and 7 feet apart, and the individual piles set 5 feet apart in the rows.

Reenforcements. The reenforcements of the floor of the flume shall be of twisted square steel bars, the bars between the round rows of piling shall be 1 inch in diameter and those running lengthwise shall be spaced 18 inches apart and be ⅞-inch in diameter.

The wire reenforcement shall be of 4-inch wire mesh No. 5.

Construction. The entire construction shall be concrete except the gate frame and the gate.

The gate frame shall be of 3 by 6-inch short-leaf pine bolted flush to the opening.

The gate shall be built of tongued-and-grooved short-leaf pine 7 by 4 feet. 5 inches composed of two layers; the inner one being 3 inches thick and 7 feet long, the outer one being 2 inches thick and 3 feet long. The gate shall be hung in the gate-well over the opening with a pair of suitable link hinges so that it readily opens at low tide and tightly closes on high tides. The gate and the gate frame shall be of the best workmanship.

Height. The flume floor shall have a fall of 6 inches and the box shall be set as low as the shoal sea bottom will permit.

Cost of Concrete Gate as Planned:

Reinforced concrete in place	$2200 00
Round piling and front sheet-piling	500 00
Lumber, bolts and nails for outer flume (bay side of structure and gate)	400 00
Labor in building outer flume	100 00
Incidentals	300 00
	$3500 00

III. COUNTY MOSQUITO COMMISSION WORK

Under authority of Chapter 104, Laws of 1912, and Chapter 123, Laws of 1919, the following counties now have commissions actively engaged in mosquito-control work: Hudson, Bergen, Passaic, Morris, Essex, Union, Middlesex, Monmouth, Ocean, Atlantic and Cape May. Hudson, Bergen, Essex and Union are making satisfactory progress in their efforts to eliminate the breeding of all species of mosquitoes within their limits. Atlantic County is rapidly completing the drainage of her immense area of salt marsh and is carrying on a successful campaign against fresh-water mosquitoes in the vicinity of Atlantic City. The Passaic County commission, in whose territory only fresh-water species breed, on account of a small appropriation limits its control work to the southern more densely populated half of the county. In Monmouth, Middlesex, Ocean and Cape May counties nearly all available funds are expended on salt-marsh control work. Two years of preliminary survey work have been completed by the Morris County commission and a control campaign was carried on last summer in the vicinity of Morristown.

Hudson County

Hudson County consists of two high ridges between which lies the wide flat Hackensack Valley, made up almost entirely of salt marsh. More than half a million people live on the two ridges; almost the entire 10,000 acres of marsh is potential breeding ground for salt-marsh mosquitoes, and certain large portions of the meadows by reason of sewage pollution are potential breeders of the house mosquito. The ridges are for the most part naturally well drained but the house mosquito breeds in certain of the streams, in sewers, catch-basins, cesspools, rainpools and dumps.

Mosquito control in Hudson County involves, thus, the elimination of breeding on the 10,000 acres of salt marsh, the drainage or filling of small breeding areas on the upland and the oiling of such places as sewers and catch basins where no other control measures can be employed.

Upland Work

The commission reports the permanent elimination by filling of a large number of fresh-water pools on the upland during 1919. The upland work is reduced to the control of breeding in sewer basins, flooded cellars and sundry receptacles always to be found on the property of industrial plants and the inhabitants in general. Although every year there are many thousands of water-holding receptacles permitted to accumulate, it is believed that through the commission's activities efforts are made in numerous instances to avoid establish-

ing such breeding places. Much still remains to be done, however, to bring the people in general to a realization of the importance of care and attention in this direction.

During the past year the commission succeeded in having filled by the Central Railroad a large troublesome swamp on their property in lower Jersey City, south of the Morris Canal, thus permanently doing away with a bad breeding area which had required careful watching and the frequent use of oil. A similar breeding place on the property of the Public Service Corporation in Hoboken was filled by this corporation at the suggestion of the commission.

Considerable trouble was experienced at the beginning of the season with rain-water breeding in casks standing about the premises of several barrel factories. With the cooperation of the companies concerned, this trouble was remedied. There was also much *pipiens* breeding last summer in flooded cellars in lower Jersey City and Hoboken adjacent to the Hudson River. However, by constant vigilance and the use of oil the emergence of any considerable number of mosquitoes was prevented.

Salt-Marsh Work

The salt marsh of Hudson County is divided by the Hackensack River into an east and a west section.

The eastern section may be subdivided into three portions on the basis of the sort of drainage that has been employed. The first section begins at Newark Bay and extends northward between the highland and the river to Snake Hill. The eastern boundary of this section leaves the highland with the appearance of the Erie Railroad tracks and follows them northward to Snake Hill. This area has been drained by the usual open-marsh ditching and the systems established appear to work very satisfactorily.

The second section begins with the Erie Railroad tracks and extends northward between the Secaucus highland and the Jersey City Ridges to the Paterson Plank Road. This area of marsh is known as the Penhorn section. It is entirely enclosed and inadequately outletted under the Erie tracks at one end, and the Paterson Plank Road at the other, and is highly polluted with sewage. A great deal of the open type of ditching has been put in this section but has never worked satisfactorily because of the inadequate outlets. Nothing of an effective character has been done to relieve conditions on this marsh for the last two years.

The third section begins at the Paterson Plank Road and extends northward, west of the ridge, to the northern boundary of the county and southward between the Hackensack River and the Secaucus highland to Snake Hill. This area in previous years was drained by the open system of salt-marsh ditching with apparently pretty satisfactory results. No new work has been installed on this meadow for the last two years.

The salt marsh west of the Hackensack River is divided into a number of different areas by railroads and roadways, and has been shut off from the tides by dikes and fills. Beginning at the southern end on the shores of Newark Bay the first area extends northward between the Hackensack and Passaic rivers to the Lincoln Highway. This section has now been almost entirely taken up by industrial fills and can no longer be considered a salt-marsh mosquito breeding territory.

The second section begins at the Lincoln Highway and extends northward to the downtown line of the Pennsylvania Railroad. A very large portion of this area has been filled, but the northeastern portion is still salt marsh and such breeding as occurs on it must, under present conditions, be taken care of by the use of oil. It is probable that this area will soon be completely filled.

The third area begins with the downtown line of the Pennsylvania Railroad and extends northward between the highlands of Harrison and the downtown line of the Pennsylvania Railroad to the Harrison turnpike. This section is drained by a system of ditches. On the west side of Frank Creek the ditches lead directly into the creek itself and deliver by gravity. On the east side of Frank Creek, a much larger area, the ditches are led to a 4-inch centrifugal pump, and by pumping the water is elevated into Frank Creek. The drainage of this area is not yet entirely satisfactory.

The fourth section begins at the Harrison Turnpike and extends northward between the uplands of Harrison and Kearny on the west and the uptown line of the Pennsylvania Railroad and the Belleville Turnpike on the east, to the Greenwood branch of the Erie Railroad on the north. This is an immense area divided into two parts by Frank Creek. The portion on the east side of Frank Creek is very large and the present ditching system leads the water in two directions. One outlet is by way of Dead Horse Creek through an old sluice and tidegate into the Hackensack River. The bulk of the water, however, is led to a 12-inch centrifugal pump on the east bank of Frank Creek and elevated into that creek. A 36-inch pipe under the Newark and Paterson Branch of the Erie Railroad near Frank Creek, which was high enough to hold back much water, was lowered during the past year by the railroad company through the solicitation of the commission. This improvement opened up about 1,000 acres of cat-tail and wild-rice swamp lying north of the railroad. A considerable number of lateral ditches were cut from the main ditch which had previously been run through this territory, thus connecting it with the 12-inch pump. A concrete block house 20 feet 3 inches long by 12 feet wide, and a concrete sump and run-way, 24 feet long, 5 feet wide and 9 feet deep were constructed last winter for the 12-inch pump. This area east of Frank Creek is undoubtedly in a much better condition than it was a year ago, but much drainage work is still necessary before it can be considered reasonably mosquito proof.

The new 6-inch centrifugal pump on the east bank of Frank Creek referred to in last year's report, with its concrete house and sump, has been completed. The house is 12 feet 9 inches by 10 feet 6 inches, and the sump is 10 feet 6 inches by 5 feet 4 inches by 7 feet 6 inches with concrete bottom. Frank Creek from the outfall of the concrete flume at Schuyler Avenue to the Harrison Turnpike, and the Bergen Avenue, Tappan Street and Duke Street sewers, were cleaned and widened by the town of Kearney during the year.

All drainage water in the area north of the Harrison Turnpike and between the upland on the west and Frank Creek on the east is to be led by a system of ditches to the 6-inch pump referred to above. Most of the ditches have now been completed. This troublesome area should be comparatively free from mosquito breeding in the future.

Tht fifth area begins at the Greenwood Lake branch of the Erie and extends northward between the highland to the west to the Belleville Turnpike. Owing to the fact that the outlet was inadequate the ditching system installed on this meadow previous to the present year has never worked well. House mosquitoes, fresh-water swamp mosquitoes and salt-marsh mosquitoes still breed extensively in this area. The new drainage canal in salt-marsh section 6, described below, has improved conditions materially in the fifth area, but further drainage work is necessary before this area can be considered safe.

The sixth area begins at the Belleville Pike and extends northward to Sawmill Creek and eastward to the Hackensack River. Although an immense amount of ditching had been installed in this area previous to 1918, drainage was far from satisfactory. In last year's report new sluices and tide-gates for the outlet of Sawmill Creek were described. Before full advantage could be taken of these new sluices it was found necessary either to dredge out a considerable portion of the channel of Sawmill Creek or to cut a new outlet ditch. The latter plan was adopted as the cheaper. Since the Arlington Plant of Du Pont de Nemours & Company turns its waste water into salt-marsh section 5, referred to in the preceding paragraph, and since the only outlet for section 5 is Sawmill Creek, it was thought that the Du Ponts should bear part of the expense of cutting the new ditch. For the new canal an old 30-inch ditch was utilized in part. The old ditch was widened to 60 inches and connected with the drainage system at the Belleville Turnpike culvert. The total length of the new ditch is 8,450 feet; the work cost $2,475, of which the Du Pont Company contributed $800.

Section 7 begins with the Greenwood Lake Branch of the Erie and extends south between the Belleville Turnpike and the river to the uptown line of the Pennsylvania Railroad. An insufficient amount of ditching has been installed in this area.

The eighth area begins with the uptown line of the Pennsylvania Railroad and extends southward between the river and the said line of the railroad to the Delaware, Lackawanna and Western Railroad.

This area consists of three different bodies of marsh all dependent on the same outlet, with the exception of a small portion near the river just north of the Delaware, Lackawanna and Western Railroad. The outlet is Dead Horse Creek and this creek, in addition to serving as an outlet for these areas, serves also as an outlet for the eastern end of section 4 and a portion of section 6. The old sluice and tide-gate through which Dead Horse Creek empties into Hackensack cannot adequately take care of the entire region just described. The entomologist's office suggested to the Hudson County commission over two years ago that a centrifugal pump or pumps, with proper sumps, be installed at the mouth of Dead Horse Creek. Only by this means, with a very considerable extension of the present ditching system, can the salt marsh outletting through Dead Horse Creek be unwatered sufficiently to prevent mosquito breeding. It is hoped the commission will see its way clear to make these improvements in the near future.

Status of the Work at the End of the 1919 Season

Thus, while 65 or 70 per cent of the Hudson salt marsh is pretty well drained, much work remains to be done.

During the year, 145,488 linear feet of new ditching was cut. The cost ranged from 3 cents per lineal foot in clear meadow to 12 cents in stump-lot meadow. Also, 22,335 linear feet of old ditches were cleaned and repaired, costing from 3 cents to 12 cents per lineal foot.

Breeding was found on the meadows as early as March 10 in the spring of 1919. The commission reports, however, that no annoying emergence took place until July 10. About that date *pipiens* became troublesome in the northern part of the county. With this exception only a few mosquitoes were to be found on the wing in the county until July 26. The commission was unable adequately to cope with the breeding situation created by the unusually heavy precipitation of late July and early August. As a result the July brood of mosquitoes was very troublesome, particularly west of the Hackensack. The species predominating in order of importance were: *pipiens, cantator, salinarius* and *sollicitans*. The county, as in the preceding year, was entirely free from *Anopheles* throughout the season and no cases of malaria were reported.

Bergen County

The eastern and western ridges of highland with the Hackensack Valley between, so characteristic of Hndson, continue northeastward into Bergen County. The eastern ridge runs, maintaining its relationship to the Hudson River, to the northeastern border. The western ridge continues almost to Cherry Hill where it bends to the northward and continues in that direction until it finally reaches

and joins the broad highlands that extend to the state line. The Hackensack Valley continues northeastward to the state line, forming some swampy lands in the northern part. To the northwestward of this ridge and northeast, east and southeast of Paterson, is an area of comparatively low elevation. To the northwest the county becomes rugged.

There is much wooded territory and many woodland pools—a condition which gives to Bergen County a serious woodland-pool mosquito problem.

Many swamps of greater or less size exist, some of which undoubtedly breed the swamp species of mosquitoes prolifically. Bergen County has a swamp-mosquito problem of some size. The bulk of the population is located in the southern part of the county, but is not greatly concentrated. The water pollution, however, when taken with the usual breeding places of the house mosquito, is sufficient to furnish every town of considerable size with a pest of that species.

At some points in the county there are undoubtedly breeding places of the malarial species, such as appeared in the area where Camp Merritt is located. There are doubtless others.

The mosquito problem of Bergen County, therefore, involves the control of woodland pool species, fresh-water species, house mosquitoes, malarial mosquitoes and the salt-marsh species of mosquitoes.

Passaic County

Passaic County on the map has roughly the shape of an hour-glass with the small end to the southeast. All south of Pompton Lakes forms the southern division and all north the northern portion. Considerably more than one-half the area lies in the northern section but approximately 91 per cent of the inhabitants live in the southern part.

The surface from Paterson south, while rolling, is not rugged, but from Paterson north it assumes a rather rugged character.

The hilly portions are well wooded and have many pools. The woodland-pool mosquitoes must form a serious problem in the rougher parts of the county. No thorough investigations of this point have been made.

A considerable number of small swamps exist in the southern part of this territory and the Great-Piece Meadows are only a few miles away. The swamp-mosquito problem is a rather important one.

Because of the concentration of the population in the southern end of the county the usual breeding places for the house mosquito are abundant. Also, the cities of Paterson and Passaic have a very large number of factories in which numerous water-holding receptacles are kept. The soil is by nature fairly well drained, but is sufficiently tight to hold water in depressions long enough for mosquitoes to breed.

One of the most difficult mosquito problems Passaic County has to meet is the control of *pipiens* breeding in the Passaic River. This is perhaps for much of its length, the worst polluted river in the United States. Raw sewage and factory waste make the stream uninhabitable for fish, but render it an ideal breeding place for the house mosquito. There are times when large areas are found breeding from bank to bank.

The mosquito problem thus involves the control of the woodland-pool species, the fresh-water swamp species, and the house mosquito. There is no salt marsh in the county but invasions of salt-marsh mosquitoes from neighboring counties are sometimes troublesome.

On account of the limited amount of money available and the concentration of the population in the southern end of the county, the mosquito commission confines its efforts at control to the southern part of the county. Most of the control work of the Passaic commission is of a temporary nature. The available funds have thus far permitted only a minimum amount of permanent elimination work, such as ditching or filling.

Inspection

The part of the county in which control work is carried on is divided, as is usual, into districts. Previous to the season of 1919 an inspector was placed in charge of each district. This plan made it difficult to keep in close touch with the man and also caused much loss of time in moving the oiling truck and crew from place to place. In 1919 the plan was adopted of placing sufficient inspectors under a foreman to complete the inspection of a district in one day. This method makes it possible for the foreman to keep in constant touch with the men and any breeding found can be immediately attended to by a following oiling crew.

The rather dense urban population in the southern part of the county and the numerous factories in the vicinity of Passaic and Paterson make the inspection work in Passaic County very heavy. For the 1919 season approximately 180,000 backyard inspections are recorded in the commission's report.

The first breeding, in this case *sylvestris,* was reported on March 20. Soon after this date the oiling of pools and swamps was started for the purpose of preventing any emergence from early breeding. From April to the close of the 1919 season all pools and swamps considered dangerous were sprayed with fuel oil at 10-day intervals. In the city of Paterson, also, some 380 sewer catch-basins were oiled at 10-day intervals. The Passaic River was oiled whenever and wherever inspection revealed breeding. Approximately 8,606 gallons of fuel oil were spread during the season.

For the purpose of draining mosquito-breeding pools and swamps, many feet of new ditching were cut during the year and many old ditches and water courses were cleaned and regraded. Thus considerable permanent elimination work was accomplished.

Much of the time of the commission's field force was taken up with the discovery and elimination of breeding places found in backyards and manufacturing plants. Such breeding places are difficult to eliminate. Barrels and tubs are emptied, pails removed and cans destroyed. Yet at the next inspection the number is often as great as before. The education of a certain portion of the public in these matters is a slow process.

Cost of the Year's Work

The Passaic County Mosquito Commission spent for all purposes during the fiscal year ending October 31, 1919, a total of $16,225.09. The whole of this amount consisted of appropriations by the Board of Freeholders.

Effectiveness of the Control Work in 1919

From May 29 to about June 20, the county suffered from an invasion of *cantator* bred on the salt marshes of neighboring counties. Weekly night collections during this period showed that from 75 to 100 per cent of the mosquitoes on the wing were *cantator*. Of the fresh-water species *sylvestris* and *pipiens* predominated. During the latter part of June there were, however, few mosquitoes of any kind in the protected area. From July 1 to August 7 the county was comparatively free from mosquito annoyance. From August 7 to August 21 there was a marked increase in the number of mosquitoes caught in the commission's weekly night collections. This increase, as in other counties, is directly traceable to the continuous and heavy precipitation of late July and early August. During September few mosquitoes were present.

On the whole, with the exception of the invasion of the spring brood of *cantator*, Passaic County enjoyed a greater freedom from mosquito annoyance than ever before. The work of the commission seems to be effective in holding breeding down to a minimum within the protected area.

Essex County

Essex County begins at sea level as a 4,000-acre salt marsh and rises to the height of 600 or more feet. The lower part of the upland, between the northeastward ranging hills and the salt marsh, rarely exceeds 200 feet in elevation. Numerous streams afford the upland pretty fair drainage.

The woodland-pool-mosquito problem is an important one, for many pools are found in the well forested hilly sections. The swamp species, too, issue in considerable numbers from numerous swamps found in the valleys of the hilly and lowland sections.

To a certain extent there is also a malarial mosquito problem. Along the edges of some of the streams and ponds a heavy growth of grass occurs. *Anopheles* larvæ are found behind this grass screen.

Essex County has a population of a half-million concentrated chiefly on the lowland in and adjacent to the city of Newark. In transforming country into city, many streams have been obstructed or dammed, thus creating virulent breeding places for the house mosquito. Pollution of streams and ponds has rendered them excellent breeding places for the same species. The usual house and yard breeding places incident to a dense urban population are present. Altogether the suppression of *pipiens* breeding necessitates a very large amount of work by the Essex commission field force.

The northern border of Essex County is close enough to the Great Piece Meadows to suffer severely at times from *sylvestris* breeding in those extensive swamps.

The 4,000-acre salt marsh is crossed by numerous intersecting railways and roadways, and all natural drains, except the largest creeks, have been destroyed. Also, the city of Newark dumps much of its raw sewage on certain sections of the marsh. The blocking of streams and old ditches by roadways and industrial fills insured the abundant breeding of the salt-marsh mosquitoes, and polluting the water with sewage made certain the breeding of enormous numbers of house mosqnitoes.

Thus the mosquito problem in Essex County is seen to involve the control of the salt-marsh mosquitoes, the woodland-pool species, the fresh-water swamp species, the house mosquito and to some extent the malarial mosquitoes.

There are extensive areas of salt marsh in the Hackensack Valley, adjacent to Essex County, but while under the jurisdiction of other counties, Essex County can never be free from invasions of mosquitoes no matter how efficiently her own mosquito commission does its work, until this extra-territorial salt marsh is completely drained. Fortunately, the other counties concerned are working on this drainage as rapidly as available funds will permit.

Upland Work

The policy of intensive extermination work adopted at the beginning of the season was carried through as will appear below, and from a list of new areas permanently drained, appended to this report.

Weather conditions were favorable up to the middle of July and it can be truly said that mosquito breeding in the uplands during this period was at a minimum. From August 1 to the end of the season, while there was an increase, nevertheless breeding in quantity was fonnd only in those sections of the county which are as yet not affected by the mosquito-control work of this commission.

The inspection and control plan of 1918 was continued during 1919. The upland district was divided into sections with inspectors and assistants, who made general and house-to-house inspections, followed by oiling crews to control breeding.

Status of the Work at the End of the 1919 Season

The Essex salt marshes are the best drained, with possibly one exception, of any meadows in the state. The upland has received a larger amount of drainage, in proportion to the area, than in any other county.

The effectiveness of control measures undertaken by the commission has been largely increased and extended by the excellent cooperation the commission has been able to obtain, from owners, of mosquito-breeding areas, park commissions, departments of streets and public improvements, etc., in all matters pertaining to drainage and in the disposal of ashes and other waste materials. In this way many mosquito-breeding pools and swamps have been filled.

Considering the heavy and continuous rainfall during much of the summer and consequent increase in breeding places, the people of Essex County have no reason to complain of the mosquito annoyance and the measures taken by their mosquito commission to abate this nuisance. The extermination work was effective and held the number of mosquitoes emerging during the 1919 season down to a minimum.

Union County

Within the eastern boundaries of Union County there are approximately 4,000 acres of salt marsh. The surface of the county rises gently from sea level on these marshes to an elevation of about 600 feet in the northwest. Between the salt meadows and the northeastward-running range of hills, which is continuous with the same range in Essex, the surface is generally not more than 200 feet above sea level.

The upland of Union is not naturally as well drained as most of Essex. Swamps are greater in extent and more numerous. The fresh-water swamp-mosquito problem is consequently a troublesome one.

The woodland-pool mosquito problem, while present in the well-wooded hilly portions of Union, is not so important as in Essex.

As in Essex, malarial mosquitoes are found breeding along the grassy edges of streams and ponds.

The house mosquito is present on account of the very considerable urban population, but is not so troublesome as in Essex, Hudson or Passaic.

Owing to the fact that it is less cut up by roadways and industrial improvements of one kind and another, the drainage of the Union County salt meadows is less difficult than on the Essex County marsh. But the natural outlets have been closed or obstructed to a certain extent by the Central Railroad of New Jersey and its spurs and sidings.

The Union County Mosquito Commission at the outset of its control campaign in 1912 adopted the plan of getting rid of all permanent breeding areas in the county, by draining or filling, as rapidly as the funds at its disposal would permit, of maintaining each year all drainage systems efficiently as possible, and of preventing emergence in temporary breeding places by the use of oil or other larvicides. Permanent breeding places, of course, are water areas of such size and character that they breed practically continuously all the season, as contrasted with temporary pools, water-holding receptacles, etc., which follow heavy rains.

Inspection

Breeding was found much earlier than usual this year on account of the exceptionally mild winter. As early as February the woodland pools throughout the county were found with larvæ and adults. Salt-marsh mosquitoes were found on the salt marsh as early as April 23. Three inspectors were on duty during the early spring on the control of this spring breeding, but the whole number of inspectors was not reached until the end of June, when 7 men were employed—one in each of the six districts of the county and one on the salt marsh. Each inspector was responsible for the location of all breeding places in his district; for the temporary control of mosquito breeding by oiling; for the supervision of the ditching works, to maintain ditching and to enlarge the ditching systems with new drainage; or for the filling in of places permanently with any available filling, and the making of arrangements with property owners in regard to drainage work.

This inspection work covered every municipality in the county. All breeding places were visited once in 10 days, and oiling or drainage work completed.

For the first time since the organization of the commission so few rain-barrels, tubs, cans and other water-holding receptacles have been found in back-yards, that it was thought advisable not to carry on yard inspections, because of the cooperation of the people of the county generally. Where a hundred barrels or other water-holding receptacles breeding mosquitoes had been found when the commission was first organized, there is hardly one now; so the money which was spent in previous years in yard inspections could be saved for permanent drainage work, and the time of the inspector used in more

close inspection of the larger breeding areas. It is expected that by means of newspaper articles and other educational measures, the continued cooperation of the people of the county will be secured in keeping their own premises free of artificial containers and other mosquito-breeding places, so that it will not be necessary to spend this large amount of money needed if yard inspection work must be continued.

During the past season the inspection work throughout the county revealed breeding in 84 barrels or vats, 303 cellars, 208 cesspools, 1,415 pools, 251 brooks, 2,031 swamps and 2,240 sewer basins.

Salt-Marsh Work

The first work undertaken by the commission on the salt marsh was the cleaning of the ditching on the three meadows in the county, North Elizabeth, South Elizabeth and Linden meadow. There is approximately a million feet of ditching on these salt marshes, about one-third of which has to be maintained by thorough cleaning every year. This work was largely finished by the first of May, about 350,000 feet of ditching being cleaned.

The only point of any magnitude on the salt marsh in the county where a large amount of mosquito breeding takes places is the area south of Great Island. A new 30-inch drain has been cut east from this area to the Manahan ditch which is the natural outlet for this low-lying section. This ditch is but a temporary expedient but has helped materially in getting the water off this low land in the shortest possible time. However, it is necessary, as soon as funds will permit, to dredge out Manahan ditch and to cut a new drain of larger size from Manahan ditch westward into this bad mosquito-breeding area south of Great Island in order to get a better outlet for this last-remaining large breeding place on the salt marshes.

The dredging of Great Ditch on the North Elizabeth meadow, which had been done in the last two years, has drained off the water which formerly would accumulate along the edge of the upland from Elizabethport northward, so that this area did not cause much trouble during the past year. However, this dredging work is being fast nullified by deposition of sewage and sludge from the Elizabeth sewers.

The South Elizabeth meadow where the ditches were given a thorough cleaning early in the spring, and where some new spur drains were cut, did not produce mosquitoes except in a few places where the cattle which run at large on this meadow had trampled in the drainage ditches. Only scattered breeding was found over the Linden meadow during the year, because of the good condition of our ditching there, most of this breeding being in the vicinity of the west works of the Grasselli Chemical Company. However, industrial de-

velopments which are taking place very rapidly on this meadow must be closely watched in order that the construction of new fills for factories, warehouses and oil tanks, with the accompanying building of roads, switches, etc., may not block off the drainage systems which the commission has installed.

Inland Work

Approximately 217,000 feet of ditching has been carefully cleaned and graded on the upland distributed over several hundred jobs.

In addition several hundred thousand feet of ditches, brooks and waterways have been inspected regularly and minor obstructions, rocks, stones, leaves, etc., removed so as to get the best possible flow, and many private owners have cooperated in abating mosquito-breeding places on their own properties at their own expense. The bulk of the new work inland has been done in Elizabeth and Union townships, where the greatest concentration of population would be affected. The Union Township work which has been going on for the past two years has been continued, so that a large part of the 300 acres of land embraced in the marshes along the head waters has been made approximately dry, by cleaning out the main channel of the Elizabeth River. It is expected that this work can be completed next year, provided the cooperation of private property owners can be secured in the construction of lateral ditches on these projects.

Several municipalities have utilized their waste ashes and other materials for filling in low places in the municipal limits. The commission has prepared a list of the actual water-holding mosquito-breeding places which are available to be filled in with town ashes, and has in many cases made arrangements with the property owners on behalf of the municipality for using these places for a disposal ground. It is hoped that all of the larger municipalities of the county will take advantage this winter of this chance to do the double job of getting rid of their waste materials and wipe out mosquito-breeding places at the same time by utilizing actual stagnant-water places for dumping grounds.

Status of the Work at the End of the 1919 Season

At the present time there are somewhat less than 300,000 feet of ditching on the upland. About 60 per cent, or approximately 2,000 of the larger permanent swamps and pools of the county, have been drained or filled. Most of the upland drainage consists of open ditches, but many feet of tile-pipe have been laid. Each year in addition to maintaining the ditching about 250 miles of natural waterways are inspected and the channels kept open.

There had been installed on the salt marsh to October 31, 1919, about one million feet of ditching, 17 tide-gates and 1½ miles of dike. This drainage system is sufficient to keep almost the entire Union County salt marsh in good condition and free from breeding, at least in ordinary seasons. From time to time, however, on account of blockage of creeks and ditches by industrial fills, factory waste or raw sewage, it is necessary to install new ditching and dredge out old channels.

During the past year the salt-marsh drainage system was maintained in a high degree of efficiency. But as the result of the extraordinarily wet weather and high tides of midsummer, the meadows remained flooded long enough in certain sections to permit the escape of three broods. Portions of three broods escaped from the area immediately south of Great Island. The commission was without sufficient funds last year to widen and deepen the chief outlet to this area. It is hoped that this matter can be taken care of during the present summer.

The house mosquito was not troublesome throughout most of the county at all last summer. This was due to the efficient work of the district inspectors and the prompt oiling of all breeding places found.

Middlesex County

The elevation of Middlesex County is nowhere as great as in the counties so far considered; for the most part it is 100 feet or less but in some places as much as 200 feet. The surface is gently rolling. A red-shale belt crosses the northern part of the county. The soil in the southern part is a gravelly loam. South of the Raritan River and east of New Brunswick there is a sandy region.

Except in the sand-barren region woodlands are not extensive. Hence woodland pools are not numerous enough to make the woodland mosquitoes troublesome.

Since the population is not greatly concentrated the house mosquito problem is not a large one.

There is much poorly-drained and swamp land. Hence the fresh-water swamp mosquitoes constitute a pest in some parts of the county.

There is much breeding of malarial mosquitoes in certain sections along the grassy edges of brooks, swamps and ponds.

The most important mosquito problem in Middlesex, however, is found on the 8,000 acres of salt marsh. This marsh is not continuous, but consists of larger or smaller areas of meadow along the Arthur Kill and on either side of the Raritan river and bay. On these meadows *Aedes cantator* breeds in the spring and *Aedes sollicitans* in summer.

While the mosquito problem of Middlesex thus involves the control of the fresh-water swamp mosquito, the malarial mosquitoes and, to a certain extent, the house mosquito, the commission has devoted all available funds, with the exception of its first season, to salt-marsh drainage. There can be no question but that this policy is a sound one and gives the best results. No matter what work is done on the upland, freedom from the mosquito pest cannot be expected until the 8,000 acres of salt-marsh breeding area is drained.

Upland Work

The commission, as is its custom, offered expert oversight for locally supported fresh-water campaigns to all municipalities. The borough of Dunellen accepted the offer and appropriated $275 for 1919. Eight complete inspections were made during the season, 720 properties being visited on each occasion. This made a total of 5,760 inspections for the season. Of this total, 452 properties contained breeding receptacles which were destroyed and 521 places were oiled to prevent emergence. In addition to *pipiens* breeding, several *anopheline* or malarial breeding places were discovered, and destroyed before emergence could take place.

The season's campaign proved a success in every respect until the bad rainy season of late July. Swamps in the neighborhood of the borough, but outside of the borough limits, threw off many swamp mosquitoes (*sylvestris*). These mosquitoes caused considerable annoyance during August. But even then the absence of *pipiens* and *Anopheles* was appreciated by residents of the borough.

A two months' campaign against the house mosquito was conducted in the borough of Metuchen, under the auspices of the local board of health. House mosquitoes were controlled without difficulty, but *sylvestris*, bred in the nearby Dismal swamp, infested the town to such an extent that the effects of the *pipiens* control work was not apparent or appreciated.

Salt-Marsh Work

Spring maintenance work was started March 31, 1919, and proceeded until all of the approximately 1,000,000 feet of salt-marsh ditching in need of cleaning had been attended to.

During the year 28,173 linear feet of new standard ditching was cut by the commission's laborers on the salt marsh. The small amount of new footage is due to the fact that the appropriation in Middlesex County permits the employment of only a limited number of men. These men were kept busy most of the season on either maintenance or emergency work. The unusual precipitation made it necessary to

employ the entire labor gang in spreading oil for many days at different times during the season.

At the suggestion of the chief inspector, the Raritan Arsenal authorities borrowed the commission's power ditcher. With this machine 69,700 linear feet of standard ditching was cut on the 1,400 acres of marsh within the arsenal properties. This ditching was completed in early June, 1919. Control work was carried on throughout the season, as during the preceding summer, by the arsenal authorities.

Status of the Work at the End of the 1919 Season

As in other counties, the 1919 season was one of the most trying from a mosquito-control standpoint yet experienced. Excessive rainfall and high tides made it necessary to control salt-marsh breeding by the use of oil on five different occasions. The acid-soaked portion of the Raritan marsh was particularly difficult to control.

In spite of the numerous handicaps under which the commission labored, the salt-marsh mosquito-control work was very effective. Comparatively few mosquitoes escaped except in the borough of Roosevelt, where the drainage system has not been completed, and the Cheesequake marsh, where no work was undertaken because of lack of funds.

House mosquitoes and fresh-water swamp mosquitoes were numerous throughout the county except where work was carried on locally for their control.

Many specimens of *Anopheles quadrimaculatus*, the malaria-carrying mosquito, were found within the city limits of New Brunswick and along the western boundary of Piscataway township. Several cases of malaria developed that were no doubt due to *Anopheles* breeding in the Raritan valley above New Brunswick. The commission has not sufficient funds to care for this section. It is hoped the local township committee can find a way to remedy the situation.

The salt-marsh drainage has now reached the point where it seems reasonable to expect that the initial ditching will be completed in two or three years. The ditching still remaining to be done is scattered. About 100,000 feet additional is needed on the Cheesequake marsh and smaller amounts on the Carteret, South Amboy, Sayreville, Marquis creek and Whale creek marshes.

Monmouth County

The surface of Monmouth County is level or rolling. A range of low hills beginning at Atlantic Highlands with an elevation of about 200 or 250 feet extends southwestward across the county for some

distance before becoming lost in the general elevation. From the northern side of this range the land slopes down to Raritan bay, and from the southern side to the Atlantic ocean. The bulk of the 3,500 acres of salt marsh in the county lies behind the shallow beaches on Raritan bay or along the Shrewsbury and Navesink rivers which discharge into the bay. Smaller marshes occur on the Shark and Manasquan rivers on the Atlantic side.

The soil of Monmouth is porous and fertile. Hence it is rather intensively farmed, and woodlands are small and few in number. The woodland-pool mosquito problem scarcely exists. Nor are there any extensive areas of upland swamp to furnish a very troublesome fresh-water swamp-mosquito problem.

In some parts of the county malarial mosquitoes breed to a certain extent along sluggish water-courses. The population is dense enough to create numerous breeding places for the house mosquito. The salt marshes provide the basis for a salt-marsh mosquito problem.

The house and malarial mosquito problems are not important enough to warrant a county-wide campaign. The commission, therefore, devotes its small appropriation entirely to salt-marsh control work and acts only in an advisory, or supervisory, capacity to municipalities wishing to undertake local campaigns.

Upland Work

The boroughs of Rumson and Monmouth Beach, through the cooperation of their respective councils and boards of health, as in previous years, employed men to patrol their territories. These men located and destroyed all fresh-water mosquito larvæ. The commission supervised this work.

The borough of Freehold, in cooperation with the commission, carried on a very successful extermination campaign last summer. The results show what can be accomplished when interested authorities are backed by a majority of the residents. The town was practically free from the house-mosquito pest all summer, a striking contrast to conditions the preceding summer.

Salt-Marsh Work

Maintenance work was started on the salt marsh March 25 with a force of 11 men. Before the ditches were cleaned, all meadows, where it was safe to do so, were burned off.

Every week throughout the season the salt-marsh areas were patrolled, and all breeding was destroyed where found by either oiling or temporary drainage.

As in Middlesex County, the unusually wet season made it necessary to abandon all ditching work at times and employ the entire labor force in spraying oil.

During the season some 25,922 linear feet of standard ditching, or its equivalent, was cut.

Status of the Work at the Close of the 1919 Season

As a result of the commission's activities the salt meadows of the county are pretty well drained under ordinary conditions. As a result of the experience gained during last summer's very wet season, however, it has been decided to cut many new and wider ditches. Areas were found breeding last summer which had hitherto been considered safe.

Up to July 20 salt-marsh mosquitoes were kept under very nearly perfect control last summer. After that date it was found impossible with the funds available to prevent the emergence of some mosquitoes from the extensive new-breeding areas created by the severe storm of midsummer. But there is no doubt that the efforts of the commission kept most of the summer broods from getting on the wing.

Ocean County

Except in the northeastern portion, where the soil is a fertile loam, Ocean County lies entirely within the flat, sandy Pine Barren Belt. On the eastern side of the county lies Barnegat Bay, separated from the Atlantic Ocean by two long narrow harrier beaches. Bordering Barnegat Bay on either side, and extending inland for some distance along the streams flowing into the bay, are over 40,000 acres of salt marsh.

On account of the porous nature of the soil and the character of the water in the cedar swamps of the Pine Barrens, it does not seem as though the woodland and fresh-water swamp-mosquito problems should even be of county-wide importance. Nor is the population as yet dense enough to render the house-mosquito problem of prime importance. The Ocean County Commission therefore is devoting all its funds to controlling breeding on its enormous acreage of salt marsh.

Work of the Commission for 1919

Ditch cleaning was started as early in the season as the weather would permit. About 450 miles of ditching was cleaned and repaired wherever necessary, and 7,000 feet entirely recut. The commission's

superintendent and his assistant inspected the salt marshes at least every 2 weeks from May 1 to October 31.

During the year 150,000 linear feet of new salt-marsh ditching was cut by contract and 90,345 linear feet by the commission's force.

Status of the Work at the Close of the 1919 Season

Up to October 31, 1919, about 2,312,098 linear feet of 10 by 30-inch ditches, or their equivalent, and 325,006 linear feet of 7 by 18-inch ditches had been installed on the Ocean County salt marshes. The meadows are now fairly well drained, subject to up-keep, from Bay Head to a point south of Stafford Creek, on the mainland. Most of the territory from the southern boundary of the county at Ballinger's Creek and from the Mullica River to Tuckerton Creek has been ditched. It is estimated that about 200,000 linear feet will finish the initial drainage of these marshes. When the Experiment Station finishes the drainage between Seaside Park and Barnegat Inlet, a narrow strip of territory some 8 miles long, the ditching of the marshes bordering the barrier beaches will be complete.

It must not be inferred that the drainage in all the territory referred to above is perfect. Undoubtedly in many places the drainage system will have to be extended and corrected. The maintenance of the ditching north of Barnegat Inlet, on either side of the bay is also a difficult and expensive proposition if done efficiently. On account of the fact that there is but one narrow outlet for this upper 20 miles of the bay, the diurnal fluctuation of the tide cannot always be depended on to empty the ditches. Also much of the trenching is necessarily less than 15 inches deep on account of the thinness of the sod, and outlets are continually being blocked by sand and floating eelgrass. But it is hoped the outlet problem will be solved by a device being tried experimentally this year.

A number of times during the past summer mosquitoes were present at various places in the county. These insects were either fresh-water species or came from local areas of salt marsh in which the drainage system was incomplete or not functioning properly. About July 26 a flight of *sollicitans* from the undrained marshes south of Tuckerton, covered the territory from Tuckerton to Toms River.

An enormous brood of mosquitoes emerged about August 20, which by August 24 and 25 had pretty well covered the county. The dominant form in this flight was *sollicitans*. Undoubtedly a majority came from the 25,000 acres of undrained marsh along the Mullica River in Burlington County. But at some places, as on Island Beach there were enough locally bred *sollicitans, sylvestris,* and *pipiens* present to make life outdoors unbearable for most people without the addition of any migrants. For days before the emergence of this brood a succession of easterly storms backed the water up in the bay. This

failure of the tide-fall with the heavy precipitation, flooded all possible breeding areas along either side of Upper Barnegat Bay. In some places when the tide did fall the ditching system was inadequate to unwater the area in time to prevent emergence. It is hoped adequate provision can soon be made to prevent a repetition of the above occurrence.

In spite of the remarkable flight of August 24, the commission has no reason to feel discouraged, for before that date the county had never been so free from mosquitoes.

Atlantic County

Atlantic County, like Ocean, lies entirely within the sandy Pine Barren region of South Jersey. The flat, sandy surface, with an elevation generally under 100 feet, is largely covered with a growth of scrub oak and pine. Within the limits of the county are over 53,000 acres of salt marsh, lying along the larger rivers and bordering the coastal barrier beaches.

The woodland-pool mosquito problem, on account of the porosity of the soil, is unimportant.

There are extensive cedar swamps in the county but these have never yet been shown to breed to any extent. A few *perturbans* and *sylvestris* are occasionlly taken; so there is some fresh-water swamp breeding.

In the larger towns and cities, particularly in Atlantic City, there is a very troublesome house-mosquito problem. The commission devotes its appropriations to the elimination of this *pipiens* breeding in the larger cities, and to the control of the salt-marsh species breeding on the county's immense acreage of salt meadows, the salt-marsh work being by far the most important phase of the commission's activities.

Salt-Marsh Work

Maintenance was started with all ditching laborers on March 10. Available funds did not permit enlarging the labor gang, so it was not until late in the summer that cleaning was finished.

Atlantic County uses the standard 10 by 30-inch ditch supplemented by 7 by 20-inch spur ditches. One power ditcher was started July 16, and another in September. Up to October 31, 283,775 linear feet of new 10 by 30-inch ditches and 55,112 linear feet of 7 by 20-inch spur ditches had been cut. About 3,044 square feet of salt-marsh holes were filled during the season. The new work was placed partly between the Great Egg Harbor River and the Middle River and partly between the Tuckahoe River and the Middle River. The latter area is an extremely bad breeding marsh; it will probably be entirely drained by the summer, 1920.

Upland Work

Fresh-water work was combined during the 1919 season as in previous years, to control measures against the house mosquito. Twelve young men were employed for backyard, cellar and house inspection. This force was kept busy all summer in Atlantic City and nearby towns on the mainland. *Pipiens* breeding is exceedingly difficult to control in Atlantic City in wet seasons on account of the nature of many of the buildings, reclamation projects and garbage dumps, and the number of water-holding receptacles left lying about. There is much breeding, unless it is prevented, under buildings, in cellars and on garbage dumps.

Status of the Work During and at the End of the 1919 Season

Approximately 6,000,000 feet of standard 10 by 30-inch ditching, or its equivalent, had been installed on the Atlantic County salt-marsh to October 31, 1919. A small part of this was cut by the Experiment Station, the rest by the Atlantic County Mosquito Commission. It is estimated that the meadows of the county are 65 per cent drained. The drainage system is maintained in a high state of efficiency.

Salt-marsh breeding during the past season was first reported on March 6 at Margate. Additional drainage was completed in this area in time to prevent any emergence.

In April larvæ of *Aedes cantator* were again reported. The breeding was heavy on the undrained marshes along the Mullica River. The first larvæ of *A. sollicitans* were found in early May. A very small portion of this first brood reached the adult stage. In July two small broods of *sollicitans* matured. These broods were scattered to all parts of the county and were not numerous enough in any one place to be very troublesome.

The northeast storms of early August, accompanied by high tides and heavy precipitation, furnished the conditions in Atlantic County, as elsewhere, for the hatching of an enormous brood of larvæ. It was, of course, impossible to prevent the emergence of the brood on the still undrained meadows. Adults appeared on the twentieth. On August 22 Atlantic City suffered an infestation comparable to those of former years, before the commission began work. The following night a south wind carried a large number of these migrants to the Shore Road from Absecon to Leeds Point, a few remaining in Atlantic City for several days.

Small broods of *sollicitans* emerging in September and October were not troublesome in Atlantic County.

A few *pipiens* emerged in Atlantic City as a direct result of the August storms. Because storm-water drains were inadequate, base-

ments of hotels and apartment houses were filled with from 4 to 18 inches of water. Many of these places could not be oiled on account of furniture stored in them and consequently some *pipiens* escaped.

Cape May County

Cape May County has roughly the shape of a funnel in silhouette, with the neck of the funnel at the southern end. It lies within the sandy Pine Barren region. The surface is for the most part well wooded with pine and scrub oak, but there is more cleared land and more farming than in Atlantic County. The surface is flat and scarcely rises in elevation above 100 feet.

The woodland-pool mosquito problem hardly exists, the porous sandy or gravelly soil rendering stagnant pools comparatively infrequent.

There are many acres of cedar swamp which apparently seldom, if ever, breeds mosquitoes in appreciable numbers.

To a certain extent the open-swamp fresh-water mosquito problem must be present, for on the southwest large fresh cat-tail swamps are often fonnd bordering or emerging into salt marshes.

In the larger towns there is some breeding of *pipiens*. But the house-mosquito problem is not as important as in Atlantic County.

On the east, like Atlantic County, Cape May is bordered by extensive marshes between the Atlantic barrier beaches and the mainland. On the south and southwest disconnected but large areas of salt marsh and brackish marsh extend inland from the Delaware Bay shore. There are altogether in the county 53,638 acres of salt marsh. Hence the mosquito commission's salt-marsh problem is of paramount importance.

The commission when it began work in 1916 decided to devote all its funds to salt-marsh work. It was decided, furthermore, to begin at the southern end of the county at Cape May Point and work northwestward along the Delaware Coast and northward along the Atlantic Coast, draining all meadows as the ditching progressed. In this way relief from the mosquito pest would be afforded first to the Cape May and Wildwood districts and later to the Ocean City districts. This plan has been strictly adhered to ever since.

Season of 1919

During the year the commission has dug 116,980 feet of new standard ditching on the salt marsh and has maintained most of the drainage previously installed. Lack of funds made it impossible to clean the ditches cut by the State Experiment Station in the Ocean City and Tuckahoe districts. These are to be attended to during 1920.

Cape Island Meadows

All ditching on these meadows was thoroughly cleaned in the early part of the season.

South Cape May

A tide-gate and dike was placed in these meadows and resulted in the meadows being in a better condition than in past years. But when there are very full tides the ocean floods these meadows through a recent break in the beach, and it is impossible to realize the full effect of the drainage.

The outlets of New England Creek, Cox Hall, Shaws and Fishing Creek were kept open during the mosquito-breeding season and the meadows were in as good a condition as could be expected with the heavy rainfalls we had during the summer.

State Work

The State has placed 134,000 feet of new ditching in Cape May County during the past year. This work has been done in the Sounds meadows at Beesley's Point in the Ocean City district and in the Wildwood district.

The commission's men are now working in the Green Creek meadows. These meadows are very extensive and it will require a long time to complete this work.

Status of the Work at the End of the 1919 Season

On October 31, 1919, the meadows on the Delaware Bay shore had been ditched from Cape May Point northwestward to and including part of the Green Creek meadow. Sluices and tide-gates had been installed on the South Cape May and Pond Creek meadows. On the Atlantic Coast side the initial drainage had been installed from Cape May Point to Anglesea. In addition a large area of marsh back of Ocean City and extending westward along the south bank of the Tuckahoe River had been ditched by the Experiment Station.

The drainage so far completed is sufficient to insure the Cape May City district comparative freedom from the salt-marsh mosquito pest in ordinary seasons. The Wildwood district is insured a large measure of protection but cannot hope to be entirely relieved until the breeding areas in the Green Creek neighhorhood and further northwest are eliminated. It is a short flight across the cape from these bad breeding marshes to Wildwood. The Ocean City district has been afforded some protection by the Experiment Station ditching in [illegible] neighborhood but cannot be freed from the mosquito pest until [illegible]rainage of the Tuckahoe marshes is completed.

Morris County

In Morris County the mosquito commission has completed its econd year of preliminary work preparatory to beginning a countyide control campaign.

A very complete survey of the county has been made. This survey isclosed the fact that in the 480 square miles of territory within the ounty's borders, there are more than 33,000 acres of swamp-land. s was to be expected, the dominant species of mosquitoes were ound to be *Aedes sylvestris* and *Culex pipiens*. But in a number f localities *Anopheles quadrimaculatus* and *Anopheles punctipennis* ere found in considerable numbers. The mosquito problem of Moris County thus involves the control of the house mosquito, the openwamp species and the malaria species.

As the surface of the county is hilly there are patches of woodland. ut the woodland-pool species do not seem to be numerous enough to ause much annoyance.

As Moris County is so far inland there is, of, course, no salt-marsh osquito problem.

Before starting a county-wide campaign the commission decided o give a demonstration of control work in a limited neighborhood. orristown was selected for this demonstration. The work started he last of June and continued into the middle of August. Results ere at once apparent. From July 5 to August 10 Morristown as free from mosquitoes, although during the same period the rest f the county was suffering from the pest. The unusually heavy and ore or less continuous rainfall of early August created numerous reeding places expensive to control, and as a result all available unds had been exhausted by August 15. After this date Morristown, ike many other places in the state, suffered severely from the mosuito pest.

It is hoped sufficient funds for an efficient campaign at Morrisown will be available for the season of 1920, and that the countyvide control work may soon be started.

IV. SUMMARY OF THE YEAR'S WORK

The inspection or patrol work by the county commissions covered hroughout the season about 320,000 acres of npland and about 115,000 cres of salt marsh.

The almost continnous rains in late July and early August of last ummer made the task of mosquito extermination a particularly diffiult one. Innumerable temporary pools, non-existent in ordinary easons, were formed on the upland and in and about towns and ities. To eliminate breeding in these pools was an expensive propo-

sition for the county commissions, necessitating the spreading of much oil. Approximately 1,400 barrels of oil were used during the summer of 1919.

Notwithstanding the amount of money that had to be spent on temporary control measures a considerable amount of permanent elimination work was accomplished. A very large acreage of upland swamp was drained, but it is at present impossible to estimate accurately the amount of this drainage.

TABLE 1

Salt-Marsh Ditching in New Jersey for the Year Ending October 31, 1919

	County Comm's'n Ditching		Experiment St'n Ditching	
County	No. of Feet Cut	No. of Feet Cleaned	No. of Feet Cut	No. of Feet Cleaned
Hudson	145,488	22,335	....	....
Bergen	58,000	150,074	....	....
Essex	39,923	366,295	....	....
Union	8,000	350,000	....	....
Middlesex	*97,873	897,127	....	....
Monmouth	22,576	600,000	....	....
Ocean	336,946	10,000	90,074	....
Atlantic	311,331	5,805,003	....	....
Cape May	116,980	400,000	140,000	....
Totals	1,137,117	8,601,434	230,074	....

Total Experiment Station Ditching	230,074 feet
Total County Commission Ditching	1,137,117 feet
Total Ditching	1,367,191 feet

* 69,700 feet of this total was cut by private corporations at their own expense on the advice of the Middlesex County Commission.

In addition to cutting 1,099,117 feet of new salt-marsh ditches during the past year, the county commissions have maintained some 13,037,975 feet of trenching previously dug. Six or seven new tide-gates have been installed and some new diking constructed. Probably between 4,000 and 5,000 acres of salt marsh were drained by means of ditching or dikes and tide-gates. Heretofore an average of 9,000 or 10,000 acres per year has been maintained. The falling-off last

year was due partly to the increased cost of labor, tools and materials, partly to industrial developments on the meadows and partly to the unusual weather conditions of last summer.

Industrial developments on meadows in the northern part of the state blocked old drainage channels and made necessary the cutting of many feet of ditches in territory previously drained. The extraordinary heavy rainfall accompanied by long-continued high tides, made necessary a large amount of emergency work of a temporary character on the salt marsh, as well as on the upland.

Table 1 gives the details by counties of the salt-marsh drainage for the year ending October 31, 1919.

For the fiscal year ending October 31, 1919, the active county commissions spent a total of $243,384.71. This sum is 37 per cent of the $653,777.52 which could legally have been spent on control work by these bodies. During the same period the State Experiment Station expended approximately $15,000 on mosquito work. The total cost of control work by the mosquito commissions was about $0.097 per $1,000 of ratables for the 11 active counties, or $0.11 per capita on the basis of permanent population (1915 census). Of the sums spent by the commissions about 12.7 per cent was devoted to administration, 17.7 per cent to inspection, 14.9 per cent to temporary elimination, 20.5 per cent to maintenance of permanent drainage work and 27.4 per cent to new permanent drainage. Tables 2 and 3 give the details of these expenditures by counties.

Of the funds expended by the State Experiment Station in 1919-20 (see financial statement), approximately one-half was devoted to the maintenance of the staff, which acts as a correlating and informational agency for local boards of health and the county mosquito-extermination commissions, and one-half to actual salt-marsh drainage.

There is no doubt that in spite of the most unfavorable weather conditions of last summer, the control work was a success throughout the state. During the latter part of the season, when the mosquito pest was at its worst, the insects were noticeably far fewer in numbers within the protected area than outside this area. Indeed, some of the small towns and larger cities experienced less trouble last year than at any time in the past 10 years. In the city of Newark, which is on the border of a 28,000-acre salt marsh, the mosquito pest during 1919 was chiefly notable for its absence. Taking the season as a whole, it can be said that the mosquito protection enjoyed by the people of the state was perhaps better than in any previous year. A summer population of over 2,250,000, or three-fourths of the people of the state, and a land area of 1,888 square miles, were given a very large measure of protection from the mosquito pest. This was accomplished at a cost of 12 cents per capita, or $125 per square mile, considering the population and area protected, if the state and county expenditures are taken together.

TABLE 2

Principal Items in the Cost of Mosquito-Control Work by the County Commissions During 1919

County	New Permanent Drainage Work		Maintenance of Drainage System		Temporary Elimination Work		Inspection		Administration	
	Cost	Per Cent of Appropriation	Cost	Per Cent of Appropriation	Cost	Per Cent of Appropriation	Cost	Per Cent of Appropriation	Cost	Per Cent of Appropriation
Hudson	$11,865.90	28.7	$2,813.55	6.8	$6,415.30	15.5	$12,846.91	31.0	$3,784.23	9.2
Bergen	8,466.61	32.6	4,115.89	15.8	2,977.80	11.4	4,566.65	17.6	4,166.61	16.0
Essex	16,647.28	23.8	16,647.28	23.8	13,766.39	19.7	10,866.99	15.5	9,052.20	12.9
Union	5,597.17	20.1	11,529.32	41.4	3,687.70	13.0	3,079.20	11.0	3,288.57	12.0
Middlesex	2,044.86	27.8	1,717.78	23.4	714.16	9.7	902.46	12.3	1,224.01	16.7
Monmouth	2,767.48	46.1	1,286.16	21.4	325.11	5.4	900.00	15.0	1,829.76	13.7
Ocean	6,162.20	52.1	2,927.71	24.7	15.96	0.1	950.00	8.0	842.54	7.1
Atlantic	6,896.94	29.1	5,883.42	24.8	3,106.17	13.1	3,200.00	13.5	3,111.19	13.1
Cape May	4,686.96	43.3	1,162.41	10.8	....	....	1,530.00	14.1	986.55	9.1
Passaic	1,934.13	11.9	1,934.13	11.9	3,868.27	23.8	4,420.50	27.2	2,673.55	16.4
Morris	....	....	....	....	1,512.25	56.9	....	....	146.27	5.5
Totals	$36,869.53	27.4	$50,017.65	20.5	$36,390.11	14.9	$43,262.71	17.7	$31,100.48	12.7

These figures are only approximate. It is hoped that the uniform bookkeeping system which it is proposed the county commissions shall use in the future, will make it possible to collect more accurate cost data.

TABLE 3

Estimate of the Cost of Mosquito-Control Work by the County Commissions for 1919

County	Land Area, Square Miles	Resident Population (1915 Census)	Population per Square Mile, 1915	Total Ratables, 1919	Amount Collectible by Law for Mosquito Work in 1919	Amount Expended for Mosquito-Control Work in 1919	Amount Spent per $1,000 of Ratables in 1919 for Mosquito Work	Population Protected in 1919	Per Capita Cost for Population Protected in 1919	Area Protected in 1919, Square Miles	Cost per Square Mile of Protected Area	No. of Years Commission Has Been at Work	Total Expenditures to Date
Hudson	43	571,371	13,288	$702,551,218	$175,637.80	$41,370.29	$0.058	571,371	$0.07	43	$962.09	7	$218,430.29
Bergen	182	178,596	981	200,121,916	50,030.47	25,932.98	0.129	178,596	0.14	182	142.49	5	101,932.98
Essex	126	566,324	4,495	700,666,675	175,163.69	69,704.89	0.099	566,324	0.12	126	553.21	8	476,549.89
Union	103	167,322	1,624	203,821,552	50,955.36	27,834.77	0.136	167,322	0.16	105	265.09	8	197,568.58
Middlesex*. .	312	144,716	464	110,020,354	27,505.08	7,329.08	0.066	135,000	0.05	311	23.56	6	38,839.08
Monmouth ..	478	107,636	225	121,136,604	30,284.15	6,000.00	0.049	58,000	0.10	125	48.00	5	32,619.00
Ocean*	637	23,011	36	24,025,123	24,025.12	11,817.15	0.491	25,000	0.47	500	23.63	5	44,817.15
Atlantic	569	82,840	146	126,015,449	31,503.61	23,698.44	0.188	400,000	0.05	450	52.66	7	163,201.44
Cape May* .	255	24,407	96	38,559,880	19,279.94	10,813.66	0.280	12,000	0.90	15	720.91	4	40,813.66
Passaic	196	236,364	1,206	216,575,173	54,143.54	16,225.09	0.074	221,000	0.07	36	450.69	6	91,488.09
Morris	475	81,514	172	60,983,050	15,245.76	2,656.26	0.043	....	.....	.....	....	2	3,787.26
Totals ..	3,376	2,184,101	......	$2,504,476,994	$653,777.52	$243,382.71	$0.097	2,334,613	$0.10	1,893	$128.56	....	$1,410,047.42

* These counties are attempting to control salt-marsh mosquitoes only.

V. PRESENT STATUS OF MOSQUITO CONTROL IN NE JERSEY

There are now 11 counties actively engaged in mosquito-cont work; the remaining 10 counties are almost, if not quite, inacti The region covered by the control work represents 47 per cent of t state's area, 76 per cent of its population and 82 per cent of t *total ratables*.

TABLE 4

Salt-Marsh Drainage Work Done by the State Experiment Station and County Mosquito Extermination Commissions to October 31, 1919

	Experiment Station Ditching		County Commission Ditching	
Date	Number of feet cut	Number of feet cleaned	Number of feet cut	Number c feet cleane
Up to and including 1912	4,740,842	None	1,356,112	470,00(
In 1913	689,842	None	879,365	1,300,00(
In 1914	296,601	None	1,290,424	919,00(
In 1915	555,916	None	1,961,539	....
In 1916	None	None	2,558,042	....
In 1917	221,272	None	1,303,074	10,099,17(
In 1918	275,862	None	922,390	....
In 1919	230,074	None	1,137,117	....
Totals	7,010,409	....	11,408,663	....

Total Experiment Station Ditching 7,010,409
Total County Commission Ditching 11,408,663

Total Ditching 18,419,072

A very large amount of permanent upland drainage has been stalled. But there are, unfortunately, no figures as to the exa amount of this for the state as a whole.

On October 31, 1919 (the date of the last county reports), t condition of the salt-marsh mosquito-control work throughout t state could have been summarized as follows:

Mosquito breeding had been eliminated, subject to upkeep of ditches, dik tide-gates and pumps on over 100 000 acres of marsh. To drain these 1(000 acres sufficiently to prevent breeding there had been cut about 14,367,1 linear feet of ditches, 10 inches wide and 30 inches deep, or their equivalei 84,320 feet of dike, 80 or more sluices and tide-gates, with a total cross-sect area of 932 square feet had been built; and one 4, one 6 and one 12-ir centrifugal pump had been installed.

Tables 4 and 5 give some details of the salt-marsh work to October 1, 1919.

TABLE 5

Status of Salt-Marsh Drainage in New Jersey, 1919

County	Total Area	Drained or Not in Need of Draining	Undrained
	Acres	Per Cent	Per Cent
udson	11,468	64	36
ergeu	8,378	70	30
ssex	4,631	100	....
nion	4,413	93	7
iddlesex	8,199	56	44
onmouth	3,378	97	3
ean	40,400	71	29
tlantic	53,325	65	35
ape May	53,638	39	61
umberland	52,661	4	96

At the present time a summer population of 2,250,000 is given nually a large amount of protection from the mosquito pest. The otection is, of course, more perfect in some areas than in others, it it is safe to say that everywhere within the protected zone the inbitants enjoy a much greater freedom from mosquitoes than before e control work began. The protected zone, while not continuous, mprises about one-fourth of the state's area.

To achieve the above result, the eleven county mosquito extermiition commissions, since their organization under authority of Chapr 104, Laws of 1912, have expended a total of $1,410,047.42. From 02 to June 30, 1920, the State Experiment Station has spent 54,175.00 on all phases of mosquito-control work. The early work the State Station was experimental in character. By field obrvations in all parts of the state, and laboratory histories, range flight, etc., of the various types of mosquitoes, the best control ethods were worked out. It is these control measures which have ice been applied by the county commissions in upland and saltarsh campaigns, and by drainage. At present the Experiment Stan acts as a correlating and supervising agent with respect to the unty work, as well as installing annually a certain amount of lt-marsh mosquito drainage.

VI. NEW DEVICES

The Reiley Power Ditcher

A new salt-marsh power ditcher has recently been designed by Fred A. Reiley, chief inspector of the Atlantic County Mosquito Extermination Commission. This ditcher cuts the same style of trench, 10 inches wide by 30 inches deep, as the Eaton ditcher. As in the latter machine, too, the sod is thrown out in two long ribbons, one on either side of the ditch. But the plow and power plant are very different from those used in the Eaton machine.

Reiley ditchers have been adopted by the Atlantic County Mosquito Commission in place of their two Eaton machines and by H. I. Eaton, contractor and designer of the Eaton ditcher.

VII. THE FUTURE OF MOSQUITO-CONTROL WORK IN NEW JERSEY

At the present time there are some 18,419,072 linear feet of standard ditching on the salt marshes of the state. The maintenance of this large system, constantly growing, will soon become a heavy burden on the county commission if ditch cleaning is done by hand labor. One of the minor problems to be solved in the near future is the development of some sort of power ditch-cleaning machine. This machine must be able to clean standard ditching at less than 1 cent per linear foot. No satisfactory machine has so far been constructed. During the year a committee of three of the chief inspectors from counties with the largest footage of salt-marsh ditching has been at work designing and trying out various types of ditch cleaners. This committee has reached the conclusion that a practicable machine must have some sort of power-driven elevating mechanism to raise and deliver the soft muck formed in most old trenches. It is hoped that a cleaner built along these lines can be constructed and tried out before the end of the present year.

Another salt-marsh problem of no importance except in localities where much haying is done, is to find an economical method of removing and disposing of sod thrown out by ditching machines or hand-spades. If the sod is not removed from the meadows it drifts about with storm tides and is deposited on the marsh in such quantities and in such a way as seriously to interfere with cutting and harvesting the salt hay.

There are, of course, two phases of the problem of mosquito control in New Jersey. The first is the elimination of the breeding of salt-marsh species, and the second the suppression of the fresh-water

or upland species. These two phases of control work are not of equal importance. In most sections of the state the suppression of upland mosquitoes is purely a local matter. These species do not, as a rule, fly far from their breeding grounds. Except in a few localities, where there are extensive areas of fresh-water swamp, the upland species rarely migrate more than a mile or two from the pool or swamp where they emerged. Where, however, there is dense breeding over a considerable area as sometimes happens in the Great Piece Meadows in the Upper Passaic Valley, the fresh-water swamp mosquito, *Aedes sylvestris*, has been shown sometimes to migrate distances of five or more miles.

But long-distance migrations of even *sylvestris* are probably of rare occurrence. It seldom happens, therefore, that fresh-water mosquitoes bred in one county, unless breeding is exceedingly intensive and extensive, migrate far into another. Fresh-water mosquito control is consequently a problem of municipal or county agencies. And it may be said in passing that most of the county commissions, often in cooperation with municipalities, are doing effective work in controlling upland breeding.

The control of the salt-marsh species is quite a different matter. There are in New Jersey some 296,000 acres of salt marsh. These meadows extend from Newark Bay many miles up the Hackensack Valley, are found in extensive areas on either side of Raritan Bay and along the Shrewsbury, Navesink and Manasquan rivers. From Bay Head at the north end of Barnegat Bay, they extend in a more or less continuous 80-mile strip behind the Atlantic barrier beaches to Cape May Point on the south, and thence up the Delaware Bay Shore in discontinuous but large areas, for some thirty or forty miles. The whole of this immense area is potential breeding ground for salt-marsh mosquitoes. These salt-marsh species moreover, are far-flying forms. Migrations of 30 miles or more are of regular occurrence. Before control work was begun, from two-thirds to three-fourths of the state was subject to visitation by salt-marsh species. These mosquitoes do not respect county lines, and their suppression is a matter of state-wide importance and not a purely local matter.

Hence the most important problem which the Experiment Station and the county commissions are facing is the completion of the initial drainage of the salt marshes of the state within a reasonable time. This can be accomplished only by a large measure of state aid. The counties are already doing their share.

It is estimated that there are from 145,000 to 150,000 acres of salt marsh in the state remaining to be ditched. Last year but 5,000 acres were added to the area of drained marsh. An average of about 9,000 acres per year has hitherto been maintained. Even at this higher rate it will take about 15 years to complete the initial drainage.

At present prices the mosquito drainage of the meadows can be completed for $1,000,000 or less. That is to say, an annual appropriation of from $150,000 to $180,000 by the state, in addition to what the counties are already spending, would suffice to complete the job within 5 years.

In view of the fact that it has been estimated by the Department of Conservation and Development and others, that the completion of the mosquito drainage of the salt marshes would result in an increase of taxable values amounting to $5,000,000,000 within 20 years, $1,000,000 spent on salt-marsh ditching would seem to be an exceedingly good investment of state funds.

The further possible tremendous development of New Jersey's unexcelled seashore resort resources is practically dependent on the effectiveness of salt-marsh mosquito control.

New-Style Sluice for Sandy Outlets

The outlet problem for that portion of Barnegat Bay lying north of Barnegat Inlet has been a serious one. Because this portion of the bay has but a single narrow outlet, the daily fluctuation of the tide cannot always be depended on to empty the ditches with regularity. Easterly and southerly winds have a tendency to back the water up in the bay and keep the meadow drainage ditches bank-full or overflowing. Moreover inshore, the bay is in many places very shallow and ditch outlets are continually being obstructed or closed by sand and eel-grass.

To keep the numerous ditch outlets open and functioning properly during the season is rather expensive. It was thought that sluices or flumes might stay open and prove economical. But any except those of the heaviest construction would be ripped up by the ice if they ran out in the usual way on piling above the bottom. To meet this situation the entomologist suggested that the flumes be laid under the sand, below the bay bottom and come up with a right-angle turn on the outside end after water of sufficient depth had been reached.

On ordinary meadow it is proposed to use open sluices without tide-gates, burying the culverts beneath the bay bottom as outlined above. A number of feet of wooden sluice of this type has already been constructed under the direction of this office, and will soon be installed by the Ocean County commission.

At a number of places on Island Beach, which separates Barnegat Bay from the Atlantic Ocean, the bay beach forms a natural dike. Behind the dike are found marshes of varying character and size. At the outlet of one of these swamps 2½ miles south of Seaside Park a sluice and tide-gate of a type suggested by the entomologist, has

been installed experimentally under the direction of this office and with the cooperation of the Ocean County commission. A box-well of 2-inch yellow pine, with a tide-gate, was constructed in the beach. A wooden sluice runs from the well out under the beach and bay bottom until sufficient depth is reached, and then comes up with a right-angle turn for 4 or 5 inches above the bottom. It is hoped that the 4 inches of outlet end, the only part of the culvert above the sand, is deep enough to escape injury from ice. It is expected also that the operation of the automatic tide-gate will dry out the soft areas in the swamp behind the beach so that ditches will stand up better and so that the marsh will act as a sponge reservoir and be able to take up all precipitation.

VIII. MOSQUITOES OF THE YEAR

The spring broods of salt-marsh mosquitoes for the 1919 season caused very little annoyance within the protected area. In the south the May brood consisted of *cantator* and *sollicitans* with *cantator*, as usual, predominating. In the north the May brood consisted almost entirely of *cantator*. The June brood in the south was composed largely of *sollicitans* and with this brood the proposition of *sollicitans* increased in the north also.

Up until the last of July of the 1919 season, the protected area enjoyed a greater freedom from mosquitoes of all species than it had ever known. But in the early part of August, as a result of the unusually heavy and prolonged rains, accompanied by high tides, of last midsummer, mosquitoes escaped from insufficiently drained portions of both upland and salt marsh. Enormous broods were thrown off from undrained areas of salt marsh and upland swamp. As usually happens when such dense breeding over extensive areas occurs, migrations were larger and more extended than in ordinary seasons. There was, too, a heavy infestation of *pipiens* in unprotected urban centers, following the midsummer storms. Hence there was considerable annoyance about the middle of August at certain places within the protected zone from escaped and migrant mosquitoes.

The dominant salt-marsh mosquito from Union County south in the summer infestation was *sollicitans;* from Union County north, *cantator*. In urban centers north and south *pipiens* was perhaps the most troublesome species. *Sylvestris* was abundant in all imperfectly drained sections of upland.

Russel W. Gies, chief inspector for Union County, found *Anopheles crucians* breeding during the summer in the city of Elizabeth. The junior author found this same species on the beach south of Seaside Park in September. *Crucians* had never before been reported so far north in New Jersey.

For the season of 1920 there is not much to report thus far. Th usual spring broods of *cantator* and *sollicitans* have been effectivel controlled throughout nearly all of the protected zone. Little or n annoyance has been reported from escaped broods. *Sylvestris* is fairl abundant in the northern part of the state in counties with an in sufficient amount of upland drainage. In all except the norther end of the county, Essex is practically free from *sylvestris*. It i quite evident that the excellent system of drainage installed in th past few years on the Essex upland has proven effective in riddin the county of the *sylvestris* pest formerly so troublesome.

IX. NEW JERSEY MOSQUITO EXTERMINATION ASSO CIATION

The New Jersey Mosquito Extermination Association is now i its eighth year. This organization was formed by citizens of th state for the sole purpose of forwarding the work of mosquito contro Seven annual meetings have been held and the proceedings of eac published. These proceedings, of which only a limited number o copies are issued, are of considerable value to the mosquito exter minator, for in them are brought together usually an account of th latest and best control methods in use in New Jersey and elsewhere Descriptions of new devices and mechanical appliances and report of the progress and results of the work in New Jersey and other part of the world, often appear first in these proceedings.

The membership of the Association is now over 2,100.

FINANCIAL STATEMENT OF THE STATE EXPERIMENT STATION'S MOSQUITO WORK

Total appropriation		$15,000.0
Salt-marsh ditching	$6,430.00	
Advertising for proposals	55.64	
Blue-prints, photographic supplies	32.52	
Telephone and telegraph	35.60	
Postage	50.00	
Office and field equipment	544.72	
Salaries of regular and temporary employees	5,995.82	
Traveling expenses	1,704.57	
Labor and technical assistance	93.00	
Reverting to State Treasury	58.13	
		$15,000.00

REPORT OF THE DEPARTMENT OF PLANT PATHOLOGY

Department of Plant Pathology

MELVILLE T. COOK, PH.D., Plant Pathologist.

WILLIAM H. MARTIN, PH.D., Associate Plant Pathologist.

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*GERTRUDE E. MACPHERSON, Research Assistant.

* Resigned June 30, 1920.

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Report of the Department of Plant Pathology

M. T. Cook

INTRODUCTION

The organization of the department has undergone very little change since our last report on June 30, 1919.

Dr. W. H. Martin, associate plant pathologist, devotes a considerable part of his time to the study of the diseases of potatoes. His work is discussed in a special report by him on pages 577-598.

C. M. Haenseler continues with us as New Jersey Zinc Company fellow, and is getting some excellent results in his studies on fungi injurious to plants.

R. F. Poole, fellow in plant pathology, has been devoting the major part of his time to a study of the root rot of celery and the root rot of horseradish. On July 1 he will be placed in charge of the work on the diseases of sweet potatoes and tomatoes.

Miss Gertrude E. Macpherson's appointment expires with the end of this fiscal year. She presented her thesis on "Comparison of the Development of Dodder (*Cuscuta gronovii* Willd.) and Morning Glory (*Convolvulus repens* L.)," and received the degree of Master of Science in June, 1920. She also devoted a considerable amount of time to assisting the writer in his studies on the effects of bordeaux and other mixtures on potato plants, and on the brown rot of the peach. In addition, she has proven a very efficient assistant in miscellaneous laboratory duties.

Two new graduate students will assume their duties July 1, 1920. They are Wm. D. Moore and G. W. Fant, both of the class of 1920 of Clemson College, South Carolina.

RESEARCH

The research work in progress involves the following problems:

Mel. T. Cook—

1. The influence of bordeaux and other spray mixtures on potatoes.
2. Influence of mosaic and leaf roll on the yield of the potato.
3. The transmission of *sclerotinia cinerea* from year to year.
4. Causes of tomato fruit rots.
5. Removal of fruit tree cankers.

W. H. Martin—
1. Relation of sulfur to soil acidity and the control of potato scab.
2. Physiological studies of *Actinomyces scabies.*
3. Studies of physiological diseases of potatoes.
4. Relation of soil reaction to the growth of pathogenes.

C. M. Haenseler—
1. Fungi injurious to paints.
2. Spraying pears for the control of leaf and fruit spot.
3. Spraying cherries for the control of leaf spot.
4. Eggplant wilt.

R. F. Poole—
1. Root rot of celery.
2. Root rot of horseradish.
3. Control of diseases of sweet potatoes.
4. Control of the diseases of tomatoes.

The following publications have been issued from the department during the past year:

W. H. Martin. Relation of sulfur to soil acidity in the control of potato scab. *In* Soil Science, vol. 9, no. 6; June, 1920.

W. S. Krout. Common diseases of celery. New Jersey Agricultural Experiment Station. Circular 112.

Mr. Krout was formerly laboratory assistant and graduate student in the department and this circular is the result of studies made here. He is now connected with the Massachusetts Agricultural Experiment Station.

EPIDEMICS

The rainfall during the spring, summer and fall of 1919 was heavier than usual and the losses due to plant diseases much heavier than usual. Several diseases were severe enough to be listed as epidemics. They are as follows:

1. *The brown rot of the peach* was exceptionally severe in both 1919 and 1920. It is the subject for special study and is discussed more fully on page 572.
2. *The late blight of the potato* was exceptionally severe in 1919, especially on the late crop. A more complete discussion will be found on page 577.
3. *Potato scab* was more severe than usual in 1919. It is the subject of special study by Dr. W. H. Martin. His report on this subject will be found on pages 587-598.
4. *The root rot* of the pea was very severe throughout the southern part of the state in 1919. It was most destructive in Burlington County and was the cause of heavy losses. This disease occurs every year and always causes considerable loss, but in 1919 it was much more destructive than usual. It should be the subject of special study.
5. *Leaf fall* of many trees was especially severe during the spring and summer of 1919. The first complaints were concerning the beech of parks, streets and private estates, but later the complaints were made with reference to apple, peach and other trees. This entire subject is more fully discussed on pages 570-573.

6. *The leaf and fruit spot* of the pear and quince (*Fabrea maculata* (Lev.) Atk.) was exceptionally severe in 1919. Experimental work for the control of this is to be conducted by Mr. C. M. Haenseler.
7. *Stem cankers on tomatoes and cabbage* were reported from several points in the southern part of the state in 1919 and in some cases were the cause of heavy losses. The same disease was reported on peppers in 1920. It was due to *Rhizoctonia* and is primarily a seed-bed disease. Although this disease has been reported from other states, 1919 was the first year in which we have any record of its occurrence in this state.
8. *The stem rot of sweet potatoes* was no more severe than usual. It is always the cause of heavy losses and should have received attention long before this. Recent appropriations have made it possible to study this and other diseases of the sweet potato both in the field and in storage. R. F. Poole of this department has been assigned to this work, and will begin July 1, 1920.

OTHER IMPORTANT DISEASES

Because of the very wet season in 1919, a number of other diseases re of more than usual importance. They are as follows:

1. *Sun scald of the apple.* This injury was very severe throughout the greater part of the state, especially the southern half. It was due to the exceptionally high temperature on July 4 and 5. The part of the surface of the apple exposed to the direct rays of the sun became hard and black and in some exceptionally severe cases caused a cracking later in the season.
2. *Spray injury of the apple* was very severe in some orchards in which the concentrated lime-sulfur 1 to 40 was used. Self-boiled lime-sulfur used on trees of the same varieties in the same orchard gave excellent results and no injury.
3. *The black leg of cabbage* was very severe in localities in South Jersey. It is the opinion of the writer that a survey should be made to determine the severity of this disease, the amount of loss and the best methods for its control. Efforts for its control without this information are very likely to be misdirected. It is a problem for the trained plant pathologist.
4. *The root rot of celery* has been the subject of special study by W. S. Krout (formerly of this department) and by R. F. Poole. The trouble is due to two or possibly more organisms, and the symptoms are variable. It has been demonstrated that these organisms can be controlled by the proper seed-bed treatment but war conditions resulted in neglect on the part of many growers. This work is now ready for extension propaganda but the work should be carried on by a man trained in plant pathology who will be able to recognize the organisms and to overcome certain difficulties which are likely to arise.
5. *The root rot of corn* is a disease which is distributed throughout the state. It is especially severe in Salem County but occasionally causes considerable losses in other localities. We have been cooperating with the United States Department of Agriculture in the study of this disease. The records of this cooperation are appended to this report (pages 598-604). Because of the lack of funds the government support has been withdrawn but we are continuing the work.

6. *The root rot of horse-radish* is the cause of heavy losses in the northern part of the state especially in Passaic County. This has been the subject of study by Mr. Poole and is discussed on page 610 of this report.
7. *The leaf fall of the pepper* has been the cause of many complaints during the past three years. Thus far we have been unable to determine the cause of this disease but it results in rather heavy losses. It should receive careful consideration by a pathologist who can devote the necessary time to the work.
8. *The scab of wheat* causes a much greater loss than the growers realize. It is closely associated with the root rot of corn and should be studied in connection with that disease.
9. *The cherry leaf spot* was very severe, completely defoliating many trees and checking their growth before the close of the growing season. We are giving some attention to its control this year.
10. *The diseases of small fruits* are the cause of very heavy losses but are not generally recognized by the growers. A survey and brief study of these diseases followed by the proper extension propaganda would result in very great savings to the growers of small fruits.
11. *The melon and cucumber losses* due to diseases in 1919 were greater than usual. *Sclerotinia libertiana* Fckl., which is usually a serious disease on these crops when grown under glass, was quite severe in some fields. The control of some of these diseases would no doubt increase the melon and cucumber industry of the state.

COOPERATIVE WORK WITH THE STATE DEPARTMENT OF AGRICULTURE

A great deal of work of this department is very closely associated with the work of the New Jersey State Department of Agriculture.

1. *The inspection of nurseries* shows them to be in an exceptionally good condition so far as freedom from plant diseases is concerned. Our nurserymen do not handle the chestnut stock; a phase of the industry which was destroyed by the chestnut blight.
2. Very few of the common or European *barberries* are to be obtained in our nurseries, partly because of the quarantine restricting their shipment and partly because the Japanese barberry is a much more desirable plant for ornamental purposes.
3. *The blister rust on the white pine* has not been found in the state except in four nurseries. The blocks of trees in which it was found are under quarantine. The disease has been found on currants in two places, which also are quarantined.
4. It is impossible to inspect the nurseries for *crown gall and hairy root* but we have every reason to believe that very little if any of this disease goes out from the nurseries of the state. However, it is necessary to conduct very rigid inspections for this disease on stock coming into the state.
5. There has been some agitation in the state for an inspection of peach orchards in an effort to reduce *peach yellows and little peach*. The writer is inclined to believe that work of this kind cannot be carried on successfully at this time.
6. During the past year we began the inspection of *home-grown seed potatoes*. This work is very promising and a complete statement can be found in the reports of the State Department of Agriculture.

NEEDS OF THE DEPARTMENT

The force of workers in this department is not large enough to meet the many demands on us. The most urgent needs are as follows:

1. We need a well trained extension plant pathologist who can care for many calls which must now be cared for by those whose time should be given to research work. We wish to emphasize that the man in charge of this work should be a trained plant pathologist; a man who can recognize the diseases in their many variations, a man who can distinguish between diseases showing very similar symptoms although due to radically different causes, a man who can diagnose causes for failures in demonstrations and who recognizes the importance of environmental factors. Extension work on plant diseases by men not trained in plant pathology has resulted and will continue to result in more or less blunders and waste of public funds.
2. We need a man to conduct experimental work on strains resistant to diseases. This very important field is receiving a great deal of attention in the departments of plant pathology of many other agricultural experiment stations. Such a man should be well trained in plant pathology and should also have some knowledge of genetics. This is one of the most promising fields for research at the present time.
3. Many of our most important diseases are due to soil organisms. These forms are receiving a great deal of attention throughout the country. They present a number of very promising lines of study and we should give more attention to them.
4. The wilt diseases are becoming more and more important from year to year. They are usually due to soil organisms and should be studied by a well trained plant pathologist.
5. The mosaics and similar diseases (peach yellows, little peach, etc.) are very little nearer solution than they have been for many years past. They present very important and very difficult problems for research.
6. The diseases of grains and forage crops are causing much greater losses than we realize and should receive attention.
7. The diseases of small fruits are also taking heavy tolls and should receive attention or these industries will be greatly reduced within the next few years.
8. Many of the storage rots of fruits and vegetables, especially the sweet potato, are due to the same organisms that cause heavy losses in the field. They are of great economic importance and should be studied by well trained men.

THE HERBARIUM

The herbarium, which was at one time an exceptionally good collection of plants for study, has been neglected for many years. The mounted plants should be gone over very carefully and put in place and the large collection of unmounted plants should be mounted and carefully distributed so that they can be used. Prof. G. W. Martin has given some attention to this work during the past year but his time has been very limited.

DISEASES OF THE YEAR

Alfalfa

LEAF SPOT (*Pseudopeziza medicaginis* (Lib.) Sacc.). This disease wa very severe but probably no more so than in previous years. The disease leaves fall more readily than healthy leaves and the loss is quite heavy.

OTHER LEAF SPOTS due to various causes which have been recorded i previous reports were found occasionally but were of no importance.

ROOT ROTS were found and were no doubt the cause of some troubles.

Ampelopsis

LEAF SPOT (*Phyllosticta ampelopsidis* Ell. & Mart.). This disease wa very prevalent, especially on the lower leaves of the plant. Other leaf spo were of no importance.

Apple

CROWN GALL AND HAIRY ROOT (*Pseudomonas tumefaciens* S. & T.). Cor mon on the apple and many other plants. Sometimes the very evident cau of weak and short-lived trees.

BLACK ROT (*Sphæropsis malorum* Pk.). Very common but no more seve than usual.

BITTER ROT (*Glomerella rufomaculans* (Berk.) S. & van S.). More seve than usual.

BLOSSOM END ROT (*Alternaria sp.*). Very common but not serious.

JONATHAN SPOT (*Alternaria sp.*). Very abundant.

FIRE BLIGHT (*Bacillus amylovorus* (Burr.) DeToni). Less severe than f several years but very destructive in some few orchards.

BLOTCH (*Phyllosticta solitaria* E. & E.). More severe than usual. Mo common on the Smith Cider.

SOOTY BLOTCH (*Phyllachora pomigena* (Schu.) Sacc.). Common in ne lected orchards.

SCAB (*Venturia inequalis* (Cooke) Wint.). Common, especially in ur sprayed orchards.

RUST (*Gymnosporangium juniperi-virginianæ* Schw.). Very severe in few localities.

PINK ROT (*Cephalothecium roseum* Cda.). Common but of little ir portance.

FRUIT SPOT (*Cylindrosporium pomi* Brooks). Occasional.

STIPPEN (?). Very common.

WINTER INJURY. Very common.

SPRAY INJURY. Very common when concentrated lime-sulfur 1 to 40 wa used (page 571).

WATER CORE (?). Occasional.

SUN-SCALD. Very common; due to exceptionally hot weather during Jul 4 and 5, 1919 (page 559).

Asparagus

RUST (*Puccinia asparagi* D. C.). Occasional.

DWARFING. Short, weak shoots in the early spring. *Fusarium sp.* alwa present but we are not certain that it was the cause of the disease.

Asters

YELLOWS (cause unknown). This is a disease more or less prevalent eve year.

Beans

ANTHRACNOSE (*Colletotrichum lindemuthianum* Sacc. & Magn.) (Bri. & av.). Prevalent throughout the state and destructive.
LEAF AND POD SPOTS (*Diaporthe phaseolorum* (C. & E.) Sacc.). Preva- nt, especially in the southern part of the state, but not very destructive.
DOWNY MILDEW (*Phytophthora phaseoli* Thaxter). Very abundant and vere throughout the state.
ROOT ROT (*Rhizoctonio*). Very common.
RUST (*Uromyces appendiculatus* (Pers.) Lev.). Rare.
BACTERIAL BLIGHT (*Pseudomonas phaseoli* E. F. Smith). Occasional early the season. Of no importance.

Beech

BURNING of the foliage early in the summer as a result of the low temper- ure in the early spring. Especially severe in the northern third of the ate (page 570).

Beets

LEAF SPOT (*Cercospora beticola* Sacc.). Very abundant but not considered any importance.
SCAB (*Actinomyces chromogens* Gast.). Very severe and destructive in one cality.

Blackberry

ANTHRACNOSE (*Gloeosporium venetum* Speg.). Common but of relatively tle importance.
LEAF SPOT (*Septoria rubi* West.). Common but of very little importance.
RUST (*Gymnoconia peckiana* (Howe) Tranz.). Common and sometimes structive.
(See Dewberry and Raspberry.)

Cabbage, Cauliflower and Kohlrabi

BLACK LEG (*Phona lingam* (Tode) Desmaz.). Prevalent in the southern rt of the state and very severe in Camden County.
YELLOWS (*Fusarium conglutinans* Wollenw.). Common and widely distrib- ed throughout the state but not severe.
BLACK ROT (*Pseudomonas campestris* (Pammel) Smith). Occasional.
CLUB ROOT (*Plasmodiophora brassicæ* Wor.). Occasional. Sometimes very structive.
STEM ROT (*Rhizoctonia*). One record (page 559).

Cantaloupe

(See Muskmelon)

Carnation

RUST (*Uromyces caryophyllinus* (Schrank) Wint.). Common but not ious.
ROOT ROT (*Corticium vagum* B. & C. var. *solani* Burt.). Common but not ious.

Catalpa

LEAF SPOT (*Phyllosticta catalpæ* Ell. & Mart.). Common and somet the cause of heavy leaf-fall.

Cedar

RUST (*Gymnosporangium juniperi-virginianæ* Schw.). Very abundar restricted localities throughout the state. Reported from Monmouth, Burlii and Cape May counties.

Celery

EARLY LEAF BLIGHT (*Cercospora apii* Fr.). Abundant in the celery-g ing districts throughout the state.

LATE BLIGHT (*Septoria petroselini* Desm., var. *apii* Br. & Car.). Abun in the celery-growing districts throughout the state.

ROOT ROT (*Sclerotinia libertiana* Fuckel). Occasional, sometimes seve

CROWN AND HEART ROTS (*Bacterial*). Very severe in some localities (608).

Cherry

BROWN ROT (*Sclerotinia cinerea* (Bon) Shrot.). Abundant and very structive.

LEAF SPOT (*Cylindrosporium padi* Karst.). Abundant and destructive (673).

Chestnut

BLIGHT (*Diaporthe parasitica* Murrell). Abundant.

Clover, Red

RUST (*Uromyces trifolii* (Hedw.) Lev.). Common but of no importa

Corn

SMUT (*Ustilago zeae* (Beckm.) Urg.). Very common and in some c serious.

WILT (*Fusarium* (?). Widely distributed throughout the state but severe in Salem County (page 598).

WILT (*Pseudomonas stewarti* E. Smith). Occasional in the northern of the state. Of no importance.

RUST (*Puccinia sorghii* Schw.). Occasional but of no importance.

LEAF BLOTCH (*Helminthosporium inconspicuum* C. & E.). Common.

Cowpea

LEAF SPOT (*Cercospora dolichii* E. & E.). Common.

Cranberry

SCALD (*Guignardia vaccinii* Shear.). Widely distributed and very abundant in the cranberry bogs of the state.

ROT (*Acanthorhynchus vaccinii* Shear.). More or less common.

ANTHRACNOSE (*Glomerella rufomaculans vaccinii* Shear.). *Gloeosporium* stage common.

Cucumbers

LEAF SPOT (*Macrosporium cucumerinum* C. & E.). Common and destructive.

DOWNY MILDEW (*Plasmopara cubensis* (B. & C.) Humphrey). Common and destructive.

WILT (*Bacillus tracheiphilus* Edw. Smith). Very common.

STEM ROT (*Sclerotinia libertiana* Fckl.). Occasionally found in the field. Probably due to the wet season.

Currant

ANTHRACNOSE (*Gloeosporium ribis* (Lib.) M. & D.). Very common.

LEAF SPOT (*Septoria ribis* Desm.). Common.

CANE BLIGHT (*Botryosphaeria ribis* G. & D.). Common and very destructive.

RUST (*Cronartium ribicola* Kleb.). Reported from two localities (page 560).

Dewberry

ANTHRACNOSE (*Gloeosporium venetum* Speg.). Common and sometimes severe.

DOUBLE BLOSSOM (*Fusarium rubi* Wint.). Abundant and sometimes injurious.

RUST (*Gymnoconia peckiana* (Howe) Franz.). Common and sometimes destructive.

LEAF SPOT (*Septoria rubi* West.). Very abundant but of little importance.

Eggplant

LEAF BLIGHT (*Phomopsis vexans* (Sacc. & Syd.) Harter). Abundant and in some cases destructive.

WILT (*Verticillium albo-atrum* R. & B.). Common and destructive throughout the state.

Gooseberry

ANTRCACNOSE (*Pseudopeziza ribis* Kleb.). *Gloeosporium* stage common.

LEAF SPOT (*Septoria ribis* Desm.). Common.

Grape

BLACK ROT (*Guignardia bidwellii* (Ell.) V. & R.). Abundant and severe.

DOWNY MILDEW (*Plasmopara viticola* (B. & C.) D. T.). Common but not serious.

NECROSIS (*Fusicoccum viticolum* Reddick). Rare.

Hollyhock

RUST (*Puccinia malvacearum* Mont.). Very common.

Horse Chestnut

LEAF SPOT (*Guignardia æsculi* Stewart). Very common.

Horse-Radish

ROT ROT (*Bacterial*). Very common and very destructive in one locality (page 610).

ROOT ROT (*Thielavia basicola* (B. & Br.) Zoph.). Very common in one locality (page 610).

Lettuce

DROP (*Sclerotinia libertiana* Fckl.). Common and sometimes destructive.

ROTS (*Bacterium marginale* Brown and *B. vitians*). Reported from one locality.

Lilac

MILDEW (*Microsphæra alni* (Walls.) Wint.). Very common.

LEAF SPOT (*Phyllosticta halstedii* Ell.). Common.

Maple

TAR SPOT (*Rhytisma acerinum* (Pers). Fr.). Occasional.

LEAF SCALD (page 570).

Muskmelon

WILT (*Bacillus tracheiphilus* (E. Smith). Common and sometimes destructive.

DOWNY MILDEW (*Plasmopara cubensis* (B. & C.) Humphrey). Common and sometimes severe.

LEAF MOULD (*Alternaria brassicæ* (Berk.) Sacc. var. *nigrescens* Pegl.). Common and severe.

Oak

ANTHRACNOSE (*Gnomonia veneta* (Sacc. & Speg.) Kleb.). Common.

LEAF CURL (*Taphrina cærulescens* (Mont. & Desm.) Tul.). Common and the subject of a number of inquiries.

Oats

SMUT (*Ustilago levis* (K. & S.) Magnus). Common.
SMUT (*Ustilago avenæ* (Pers.) Jens.). Common.
RUST (*Puccinia coronata* Cda.). Common.

Okra

WILT (*Verticillium albo-atrum* R. & B.). Abundant in one locality.

Pea

LEAF SPOT (*Ascocchyta pisi* Lib.). Occasional.
ROOT ROT (*Fusarium sp.*). Very abundant and very destructive. Heaviest losses in Burlington County (page 558).

Peach

BROWN ROT (*Scleratinia cinerea* (Bon.) Schrot.). Abundant and destructive (page 572).
SCAB (*Cladosporium carpophilum* Thüm.). Abundant in unsprayed orchards. More destructive to foliage than usual (page 572).
LEAF CURL (*Exoascus deformans* (Berk.) Fckl.). Abundant in orchards that have not been properly sprayed.
SHOT HOLE (*Bacterium pruni* E. Smith). Abundant in some localities.
YELLOWS. Common.
LITTLE PEACH. Common.
CROWN GALL (*Pseudomonas tumefaciens* S. & T.). Common.
WINTER INJURY. In some cases severe and dating back to 1917-18.

Pear

FIRE BLIGHT (*Bacillus amylovorus* (Burr.) De Toni.). Common throughout the state and severe in a few orchards.
LEAF AND FRUIT SPOT (*Fabrea maculata* Lev.). Very abundant and very destructive in some orchards, especially in the southern part of the state.
LEAF SPOT (*Septoria pyricola* Desm.). Abundant.
BROWN BLOTCH (cause undetermined). Common.
SCAB (*Venturia pyrina* Aderh.). Common where the orchards have been neglected.

Pepper

ANTHRACNOSE (*Colletotrichum nigrum* E. & H.). Common.
ROT (*Macrosporium sp.*). Common on fruits, especially those that have been sunburned.
MOSAIC. Common but apparently of little importance.
SUN SCALD. Common and followed by fruit rots.
LEAF FALL (cause unknown). Cause of heavy losses.

Pine

BLISTER RUST of white pine (page 560).
DIE-BACK (*Diplodia sp.*). Very destructive on Austrian pine.

Plum

BLACK KNOT (*Plowrightia morbosa* (Schw.) Thüm.). Common throughout the state.
BROWN ROT (*Sclerotinia cinerea* (Bon.) Wor.). Common throughout the state and destructive.

Poplar

LEAF SPOT (*Marsonia populi* (Lib.) Sacc.). Common.
CANKER (*Dothichiza populae* S. & B.). Occasional and of some importance.

Potato

BROWN STEM (*Rhizoctonia*). Common but not as destructive as in previous years.
BLACK LEG (*Bacillus phytopthorus* Appel). Rare.
SCAB (*Actimonyces chromogenus* Gast.). Much more abundant than usual (page 587).
EARLY BLIGHT (*Alternaria solani* (E. & M.) S. & G.). Abundant throughout the state (page 577).
LATE BLIGHT (*Phytophthora infestans* DeBarry). Very abundant and very destructive (page 577).
MOSAIC. Very severe in some fields of Giants.
LEAF ROLL. Rare; not found to exceed 2 per cent in any case.
TIP BURN. Common but less than usual.
ARSENICAL POISONING. Common and usually due to carelessness in application.
SPINDLING SPROUTS. Common. Probably due to several causes.

Quince

BLACK ROT (*Sphaeropsis malorum* Pk.). Very abundant and very severe.
FIRE BLIGHT (*Bacillus amylovorus* (Burr.) De Toni). Common.
LEAF AND FRUIT SPOT (*Fabrea maculata* (Lev.) Atk.). Abundant and very severe.
RUST (*Rostellia aurentiana* Pk.). Occasional.

Raspberry

ANTHRACNOSE (*Gloeosporium venetum* Speg.). Abundant and destructive.
LEAF SPOT (*Septoria rubi* West.). Abundant but of little importance.
CANE BLIGHT (*Coniothyrium fuckelii* Sacc.). Common and sometimes destructive.
CROWN GALL (*Pseudomonas tumefaciens* S. & T.). Abundant and destructive.

Rose

ANTHRACNOSE (*Gloeosporium rosae* Hals.). Common but not serious.
LEAF BLOTCH (*Actinonema rosae* (Lib.) Fr.). Common and very severe in greenhouses.
LEAF SPOT (*Phyllosticta rosicola* Massal.). Abundant and sometimes confused with leaf blotch.
CANE BLIGHT (*Coniothyrium fuckelii* Sacc.). Common and sometimes serious.
POWDERY MILDEW (*Sphaerotheca pannosa* (Wallr.) Lev.). Common and frequently very injurious.
CROWN GALL (*Pseudomonas tumefaciens* S. & T.). Frequent and sometimes serious.

Spinach

MOSAIC. Serious. Complicated with attacks of plant lice.

Strawberry

LEAF SPOT (*Mycosphaerella fragariae* (Tul.) Lidau). Common.
LEAF SPOT (*Ramularia tulasnei* Sacc.). Common.
POWDERY MILDEW (*Oidium fragariæ* Harz.). Occasional.
WINTER INJURY. Occasional.

Sunflower

RUST (*Puccinia helianthii* Schw.). Occasional.

Sweet Potato

BLACK ROT (*Sphaeronema fimbriatum* (E. & H.) Sacc.). Abundant and the cause of heavy losses (page 557).
STEM ROT or YELLOW ROT (*Fusarium batatatis* Wollen. and *F. Hyperoxysporum*). Abundant and the cause of heavy losses (page 557).
SCURF (*Monilochaetes infuscans* E. & H.). Very common.
ROTS (*Rhizopus nigricans* Ehr., *Diaporthe batatatis* H. & F., *Scleroticum bataticola* Tamb., *Tricoderma koenigii* and *Penicillium sp.*). Very abundant, especially in storage.
POX (*Cytospora batato*). Occasional.

Sycamore

ANTHRACNOSE (*Gnomonia veneta* (S. & S.) Kleb.). Very common. Sometimes destructive in nurseries.

Tomatoes

LEAF BLIGHT (*Septoria lycopersici* Speg.). Abundant and very destructive
FRUIT ROT (*Macrosporium solani* E. & M.). Common and very destructive.

ANTHRACNOSE (*Colletotrichum phomoides* (Sacc.) Chester). Abundant and very destructive.

STEM BLIGHT or WILT (*Fusarium lycopersici* Sacc.). Abundant in one locality.

STEM CANKERS (*Rhizoctonia*). Abundant in lower part of the state (page 559).

MOSAIC. Abundant.

LEAF MOLD (*Cladosporium fulvum* Che.). Common in greenhouses and very severe.

LATE BLIGHT (*Phytophthora infestans* DeBary). Severe in one locality.

SUN BURN. Severe at times. Followed by fruit rots.

Walnut

LEAF SPOT (*Marsonia juglandis* (Lib.) Sacc.). Abundant and cause of early fall of foliage. Subject of many inquiries.

BACTERIAL SPOT OF LEAF AND FRUIT (*Pseudomonas juglandis* Pierce). Abundant on English walnuts and the cause of many inquiries.

Watermelons

ANTHRACNOSE (*Colletotrichum lagenarium* (Passe.) E. & H.). Very abundant.

STEM ROT (*Sclerotinia libertiana*). Common in the fields. Probably the result of wet weather.

Wheat

RUST (*Puccinia coronata* Cda.). Common.
RUST (*Puccinia rubigovera* (De C.) Wint.). Common.
RUST (*Puccinia triticina* Erb.). Common.
SMUT (*Tilletia foetens* (B. & C.) Trel.). Common.
SMUT (*Tilletia tritici* (Bei.) Wint.). Common.
SMUT (*Ustilago tritici* (Pers.) Jens.). Common.
MOLD (*Cladosporium herbarium* (Pers.) Lk.). Abundant.
SCAB (*Gibberella saubinetti* (Mont.) Sacc.). Very common and destructive.

Forest and Shade Trees

LEAF FALL (pages 570-571).

FALLING FOLIAGE

MEL. T. COOK

The spring and summer of 1919 were notable in New Jersey because of the enormous amount of falling foliage and the susceptibility of many trees to spray injury. In fact, spray mixtures which had been very generally recommended and used in the past resulted in more or less injury to both foliage and fruit.

The first complaints coming to the Experiment Station was concerning the dying and falling of foliage of the beech and the apple.

All of the complaints concerning the beech and most of those concerning the apple were from the northern third of the state.

The writer visited the Essex County parks, and some of the private estates, and also examined many specimens which were submitted to him. The beech leaves showed a peculiar burning or drying along the margins and frequently between the veins. In severe cases the leaves fell in great numbers. Many of the trees suffered a very severe attack, some of them losing great quantities of foliage while others showed very little burning.

A careful study of the conditions convinced the writer that the trouble was entirely due to a period of low temperature soon after the leaf buds opened and before they were fully developed. At this particular time the protoplasmic activity was high and the cuticle not fully developed. Therefore, the leaves continued to grow to some extent and the dying of the injured cells was a slow process. The effects of this low temperature extended over a period of about six weeks. The variation in the amount of injury was dependent on the advancement of the leaves at the time of the low temperature, to the location of the trees and to the exposure.

The dying of apple leaves was not so definite as the dying of the beech leaves but practically all of the injured leaves fell. Repeated examinations failed to reveal a fungus or any cause of the trouble other than the cold weather. Only the leaves that were coming out at the time of this low temperature showed injury. The latter leaves were not injured.

These conditions should not be confused with sun scald and drought injuries which are more or less common on many trees later in the season.

Weak Trees

Trees, more especially the peach, which were weakened as a result of winter injury in 1917-18, by borers, or for want of food lost considerable foliage during the latter part of June and first part of July.

Spray Injury

Spray injury was more frequent than in past years; many mixtures causing injuries which had not given trouble in past years. Among the most important were summer-strength lime-sulfur and atomic sulfur. Arsenical burnings were also quite frequent. The self-boiled lime-sulfur did not cause burnings and gave good control in both peach and apple orchards.

Paris Green Injury

The falling of foliage in some orchards was very readily traced to paris green dust which had drifted in from the adjoining potato

fields. In these cases the injury was always most severe on the rows next to the potato field and less severe on the succeeding rows.

Brown Rot of the Peach

During the blooming period of the peach in 1919 there was an exceptionally severe outbreak of the twig and blossom blight caused by the brown rot organism (*S. cinerea*). This outbreak was most severe in the vicinity of Vineland and Bridgeton and was of very little importance in the northern part of the state. This was by far the most severe outbreak of this disease that the writer has ever observed. It was not abundant on the young shoots but destroyed great quantities of blossoms. In the majority of cases a sufficient number of blossoms remained for a normal crop, the problem being to protect those that did remain from curculio and other pests.

Many growers sprayed with self-boiled lime-sulfur or atomic sulfur at this time. It is doubtful if this checked the disease on the blossoms, although it did prevent the spread to the new wood, as will be explained later.

The blossom blight form did not persist, but was followed by a spreading into the wood and the formation of cankers in most cases where blossoms were killed. These cankers produced an abundance of gum which in some cases continued to flow until some time in August.

The blossom blight was followed by the formation of cankers at the nodes on the new growth, always beginning with basal node and gradually working toward the tip and rarely missing a node. The first evidence of the canker is the dying of the bud, followed by the falling of the leaf and then the formation of the canker. The older cankers at the base of the shoots sometimes form a girdle and cause the death of the entire new growth. In many cases cankers were formed at every node for fully two-thirds the new growth. This is one of the most important causes of the falling of the foliage during July. In some orchards 75 per cent of the new buds were killed. In the well-sprayed orchards very few cankers were formed on the new growth.

Peach Scab

Peach scab came into prominence on the fruit in July and became quite common in well-sprayed orchards in the latter part of the month. In the early part of July this disease also appeared on the leaves and increased in abundance. The symptoms were first a reddening of the foliage followed by shot hole and then by falling. This was one of the most important causes of the falling of the foliage.

Cherry Leaf Spot

This disease was very abundant and by the latter part of July many trees were almost completely defoliated.

It can be controlled by two sprayings with self-boiled lime-sulfur; first with the shuck-fall (add an arsenical), and second after picking the fruit. A third spray would be advantageous.

FIELD STUDIES ON POTATO DISEASES

MEL. T. COOK

During the past eight years the writer has been giving considerable time to a study of the diseases of potatoes. The most important diseases considered during this time are: (1) black leg, (2) powdery scab, (3) common scab, (4) *Rhizoctonia*, (5) early blight, (6) late blight, (7) dry rot, (8) weather injury, (9) mosaic and (10) leaf roll. A brief resumé of the work will be given in this paper.

(1) BLACK LEG is a bacterial disease (*Bacillus phytopthorus* Appel) which was very severe and destructive a few years ago, sometimes causing a loss of 15 per cent. This disease is very rare at the present time. It is very easily recognized and the certification work is no doubt largely responsible for its removal from the growing crops in the northern seed-producing districts. Diseased plants die very early under New Jersey conditions and rarely produce seed tubers; therefore, the growing of late-crop seed tends to eliminate it.

(2) POWDERY SCAB, which is said to be a very serious disease in Europe, was introduced into Canada, Maine and New York a few years ago. Planting diseased seed in experiments under our supervision did not produce the disease on the new crop. This was corroborated by experiments in other states.

(3) COMMON SCAB is a well-known disease which was the subject of three years' work by Dr. H. Clay Lint, formerly of this department. His work is recorded in the Annual Reports for 1914, 1915 and 1916, and in Circular 95. Work on this disease was resumed in 1919 by Dr. W. H. Martin (pages 587-598).

(4) SCURF OR RHIZOCTONIA is a very injurious disease which varies in severity from year to year. It is very generally known in New Jersey by the name of "brown stem." The black sclerotia are visible on the tubers which may be smooth and apparently normal in every way, or may be small and irregular in shape, or, in extreme cases, may have very much the same general appearance as common scab. The organism can be carried on the seed and will also persist in the soil and will attack many other plants. Our experimental work[2] shows

[2] Part of the material used in these experiments was collected in New Jersey and part sent us by Dr. W. J. Morse, of the Maine Agricultural Experiment Station.

that the amount of infection on the seed tubers is no index of th severity of the disease in the field. The severity of the disease on the growing crop varies with the character of the soil, and probably with the temperature and the moisture.

The results of an experiment on seed treatment for the control of this disease are given in table 1.

TABLE 1

Results of Seed Treatment to Control Disease—Experiment I

Row No.	Condition	Treatment	Condition of crop	Total yield. lbs.	Yield per row. lbs.	Firsts per cent	Seconds per cent
6, 7, 8, 9	Sclerotia abundant	Untreated	Very few Sclerotia	90.0	22.5	50.0	29.9
10. 11	Sclerotia abundant	Corrosive Sublimate	Clean	101.3	50.6	83.3	13.9
12. 13	Sclerotia abundant	Formaldehyde	Clean	70.0	35.0	71.0	20.0
22. 23	Sclerotia abundant Deep pits	Untreated	Few Sclerotia	75.6	37.8	77.0	16.3

The results of a second experiment are given in table 2.

The results of these experiments indicate that corrosive sublimate gives much better results than formaldehyde.

(5) Early Blight (*Macrosporium solani* (E. & M.) J. & G.) is a very common disease on both potatoes and tomatoes. The organism is both parasitic and saprophytic and is very frequently found growing on parts of plants injured by tip-burn, arsenical poisons or other factors. The disease can frequently be controlled by spraying with bordeaux mixture and can usually be delayed by this treatment.

(6) Late Blight (*Phytophthora infestans* DeBy) is one of the most important diseases of the potato in America. It attacks both the foliage and the tuber, causing the well-known mahogany rot of the latter. More or less of this disease comes into New Jersey on the northern seed every year but rarely develops on the growing

plants. In 1918 there was an outbreak throughout Mercer and Monmouth counties, and the southern half of Middlesex, but the losses were not serious. In 1919 there was a very severe outbreak throughout practically the entire state beginning the latter part of July, and gradually becoming more and more severe throughout the growing season. The losses in the early or main crop due to this disease were very slight, but the losses in the late crop grown principally for seed were very heavy. The losses in the first crop during the

TABLE 2

Results of Seed Treatment to Control Disease—Experiment II

ots	Hill	Character of seed	Treatment	Number of Firsts	Weight of Firsts	Number of Seconds	Weight of Seconds	Total
					lbs.		lbs.	lbs.
4	1-38	Sclerotia abundant many deep pits	None	109	36.67	237	16.04	51.71
5	1-38		Corrosive Sublimate	144	49.7	138	11.29	60.99
6	1-38		Corrosive Sublimate	163	56.66	156	13.87	70.53
7	1-38		None	120	40	247	22.91	66.91
8	1-38		Formaldehyde	100	33.41	216	17.83	51.24
9	1-38		Formaldehyde	147	48.63	208	14.01	62.64
10	1-38		None	116	40.49	310	19.57	60.06

last few days of July and the early part of August were complicated by the losses due to bacterial rots. Undoubtedly the greater part of these early losses were due to the bacterial rot. The Federal market inspectors found late blight rot in some of the early shipments from New Jersey, but were misled as to the amount due to this cause and the amount due to bacteria. The losses due to bacteria were very heavy in many fields in which there was no late blight. The loss due to bacteria was 90 per cent in some of the experimental plots on the Experiment Station farm in which there was no late blight. The results of the potato spraying experiments by Dr. W. H. Martin are given on pages 577-587.

(7) DRY ROT (*Fusarium oxysporum* Schlt.) is to be found every year and occasionally causes losses, but cannot be considered as one of our most important diseases. The writer has made numerous tests by planting the sound parts of potatoes partly rotted by this and other organisms. In the majority of cases the plants were weak as compared with those grown from sound tubers.

(8) WEATHER INJURIES are more or less common. One of the most important forms of weather injury is "tip-burn." It is most severe during hot weather following a wet season.

(9) MOSAIC is one of the most severe diseases on the American Giant. It is also very severe on Green Mountains and Bliss Triumphs, but these varieties are not used so abundantly in this state. Experimental tests covering a period of 5 years reveal the following facts: (1) The disease is transmitted in the tubers; (2) it reduces the yield, and (3) it increases in severity from year to year.

A few of the characteristic results of experimental work on this disease are discussed below.

Green Mountain potatoes from Maine, sent to us by Dr. W. A. Orton, of the United States Department of Agriculture, gave the following results in 1916:

Plot	Seed	Crop	Firsts	Seconds	Total yield per acre
			per cent	per cent	bushels
1	Healthy	Fine	86.10	12.80	429
2	Mosaic	52.6 per cent Mosaic	60.88	13.12	329
3	Mosaic	Severe Mosaic	66.27	33.72	169+
4	Mosaic	Mosaic	74.29	24.27	335

A study of this table shows that plants affected with Mosaic gave a lower yield than the healthy plants. The disease is not so easily detected on the Green Mountains as on the American Giants. The more prominent the disease on the foliage, the less is the yield.

The 1917 experiments were conducted with Bliss Triumphs. The seed was obtained from Maine through the United States Bureau of Plant Industry and the results are as follows:

Plot	Character	Yield per acre
1	Mosaic	73 bushels
2	Healthy	98 bushels

In 1919 tests were made with American Giants, using seed selected by the writer from the New Jersey 1918 late crop. The results were as follows:

Plot	Firsts	Seconds	Yield per acre firsts and seconds	Character
	per cent	per cent	bushels	
1	71.87	28.12	117	Mosaic
2	76.54	23.45	89	Mosaic
3	83.72	16.28	157	Healthy
4	69.80	30.2	300	

(10) LEAF ROLL of the Irish Cobblers is a very serious disease which varies greatly from year to year. Repeated experiments have demonstrated that it reduces the yield. The results in 1919 with Maine seed furnished by the United States Bureau of Plant Industry, Laboratory for Cotton, Truck and Forage-Crop Disease Investigations, gave the following results:

Plot	Character	Firsts	Seconds	Yield per acre firsts and seconds
		per cent	per cent	bushels
1	Leaf roll	25.78	74.22	57
2	Leaf roll	43.9	56.1	69
3	Healthy	53.0	47.10	132
4	Healthy	60.8	39.2	144

REPORT OF POTATO SPRAYING TESTS

WM. H. MARTIN

Cooperative potato spraying experiments were conducted by the department of plant pathology during the summer of 1919. The general plans followed in these experiments were similar to those

followed in experiments by the department during the past seven years.

In the period over which this work was carried on, twelve spraying experiments have been conducted with main-crop Cobblers; of these, eight gave positive results and four negative. The increase from spraying has not been marked, however. The average yield of the plots sprayed with bordeaux-arsenate of lead was 266.6 bushels, while the average for plots sprayed with arsenate of lead was 261.0 bushels. Spraying experiments with late-crop Cobblers were conducted three years. This crop is planted about August first and is used for seed the following year. On account of the late planting date, the crop grows under conditions similar to those of the northern potato-growing sections. The average yield of the sprayed plots was 209.3 bushels per acre, and the yield of the check plots was 199.0 bushels. Experiments with the American Giant variety were conducted for three years. The average yield for the plots sprayed with bordeaux was 354.6 bushels, and the yield of the check plots sprayed with arsenate of lead was 354.3 bushels per acre.

In the period over which these experiments were conducted the only foliage diseases which appeared were tip-burn and early blight. Considerable late blight was reported in various parts of the state in 1918, but none appeared in the fields in which the spraying experiments were conducted. The absence of late blight may account for the fact that only slight increases resulted from spraying.

This year two experiments were conducted with the main crop, one with Irish Cobblers and the other with American Giants. There was no late blight in the fields in which this work was done. One experiment was conducted with the late-planted Cobblers. This year there was a serious outbreak of late blight on this crop, the first time the disease has been reported from the section in which this work was done since 1897. At that time Dr. Halsted reported that scarcely a leaf escaped attack. As a result of the presence of this fungus in the field marked results were obtained. The vines on the sprayed plots were green for some time after the unsprayed vines were dead. The difference between the plots is clearly shown in plate 5.

Spraying Test in Cooperation with J. Harry Kandle, Elmer, N. J.

The soil on which this test was conducted is a Sassafras loam to sandy loam in excellent condition and well adapted to potatoes.

The field was planted with home-grown Irish Cobblers. One ton of a 4-8-3 fertilizer per acre was applied at the time of planting. The field was divided into 10 plots each 8 rows wide. To eliminate differences that might arise from soil variation a check plot was alternated with every two treated plots. Each treatment with the check

was repeated three times. The check plots were sprayed with arsenate of lead at the rate of 3 pounds to 50 gallons of water.

The following spray mixtures were used: home-made bordeaux mixture of the standard 5-5-50 formula and a zinc bordeaux furnished by the *General Chemical Company*, of *New York*. The proprietary mixture was used at the rate of 16½ pounds to 100 gallons of water, this being equivalent in the amount of metallic copper to the home-made mixture.

The sprays were applied with a traction sprayer that developed 150 pounds pressure. This machine was entirely satisfactory and it is questionable if higher pressure would give better results. For the first application two nozzles were used to the row, for subsequent ones an additional nozzle was used. One nozzle was pointed downward while the other two were directed inward so that the lower leaf-surfaces were covered with a film of the mixture.

Five spray applications were made on each of the different treatments. The first application was made May 31, when the plants were about 6 inches high. At the time of the second application, June 10, the plants were 18 inches high and were still free from disease. The third and fourth applications were made June 17, and 27, respectively. On the latter date, there was considerable early blight and tip-burn on the check plots with smaller amounts on the sprayed plots. The last application was made July 7; at that time, there was a decided contrast between the sprayed and the unsprayed plots. The plots were free from potato beetles at all times during the summer. Large numbers of flea beetles were present during the early summer and the copper mixtures did not appear to repel them to any marked extent.

On July 22 an examination of all the plots was made to determine the per cent of dead leaves on the different plots. It was impossible to do this for every plant, so observations were made on every tenth plant in the central row of each plot.

In table 1 is given the per cent of dead leaves for each plot as well as the average for each treatment.

The dying of the leaves may be ascribed for the most part to a heavy infestation of early blight and to tip-burn. It will be noticed that the plots sprayed with the commercial mixture had fewer dead leaves than those sprayed with home-mixed bordeaux. In this connection, it is interesting to note that two weeks before these observations were made, the plots sprayed with the home-made mixture *had fewer dead leaves than the other plots*. The marked differences in the number of dead leaves are due to the control of early blight and tip-burn. In a spraying experiment conducted on this field in 1915 by Dr. H. C. Lint, a similar contrast was obtained. From the time the differences were noticed until the potatoes were dug there was dry weather. This may account for the fact that there was no increase in yield at that time. This year, after the contrast between the check and the sprayed plots had appeared there was a week

TABLE 1

Per Cent of Dead Leaves on Each Plot and the Average for Each Treatment

Treatment	Dead Leaves			
	Series 1	Series 2	Series 3	Average
	per cent	per cent	per cent	per cent
Check	98	98	90	89
Bordeaux 5-5-50	45	45	40	44
Zinc-bordeaux	40	20	20	27

TABLE 2

Arrangement of Plots and Yield Per Acre in the Spraying Experiment With Main-Crop Cobblers

	Total Yield per acre			Yield of Firsts per acre			Yield of Seconds per acre		
	All plots	Calculated check		All plots	Calculated check	Difference due to spray	All plots	Calculated check	Difference due to spray
	bu.	bu.	per cent	bu.	bu.	bu.	bu.	bu.	bu.
Check	202.9	.....	......	176.1	.....	......	26.8	.....	.....
Bordeaux mixture	261.3	201.8	77.4	227.0	175.9	51.1	34.3	26.1	8.2
Zinc-bordeaux	253.5	200.9	79.2	212.6	175.6	37.0	40.9	25.4	15.5
Check	200.0	.....	......	175.3	.....	......	24.7	.....	.....
Bordeaux mixture	270.2	212.5	78.6	239.1	183.0	56.1	31.1	29.5	1.6
Zinc-bordeaux	275.1	225.0	81.7	232.2	190.7	41.5	42.9	34.3	8.6
Check	237.5	.....	......	198.6	.....	......	39.0	.....	.....
Bordeaux mixture	264.6	232.9	88.0	232.5	196.2	36.3	32.1	36.6	—4.5
Zinc-bordeaux	277.3	228.2	82.2	241.3	193.9	47.4	36.4	34.3	2.1
Check	223.6	.....	......	191.6	.....	......	32.0	.....	.....
Average	Bordeaux..		+18.7	Bordeaux ..		+47.8	Bordeaux..		+1.8
	Zinc-bordeaux ..		+10.3	Zinc-bordeaux ..		+41.9	Zinc-bordeaux ..		+8.7

of wet weather. As a result of this the sprayed plants, being still green, continued their growth. This may explain the fact that an increase in yield followed the spray applications this year.

The arrangement of the plots and the yield per acre for each plot are given in table 2.

To obtain a more accurate measure of the influence of the different spray treatments on yield the "calculated yield" for each sprayed plot has been computed on the basis of the yields from the adjoining check plots. The difference between the calculated yield of a plot and the actual yield has been taken as the difference due to the spray treatment.

It will be seen from the table that there was very little difference between the yields from the plots treated with the two spray mixtures. On a basis of total yields, the average increase over the check for the home-made bordeaux mixture was 49.6 bushels, while the commercial mixture gave an increase of 50.6 bushels over the adjoining checks.

Spraying Test in Cooperation with Theron McCampbell, Holmdel, N. J.

Conflicting results have been obtained in the past from spraying experiments with the American Giant variety. Of the three experiments, two gave an increase of 3 and 8 bushels per acre, respectively, while the third gave a decrease of 10 bushels per acre. This year an experiment with this variety was conducted in one of the best potato growing sections of the state. The field in which the work was done was planted with the Irish Cobbler variety in 1918. The vines did not make their growth and a poor crop resulted. Numerous reports have come to the Experiment Station of the failure of potatoes following alfalfa. In this connection, it is interesting to consider the crop history of this field for the past seven years:

1913-17—Alfalfa, 15 crops removed.

1918—5 carloads of New York horse manure added in early winter.

1918—Planted in Cobblers. Vines stunted, only about half a crop. After the crop was dug 500 pounds of 4-8-0 fertilizer per acre was broadcasted, and the field planted in wheat.

1919—500 pounds steamed bone added before the wheat was turned under. American Giant variety planted; 1500 pounds of a 4-8-3 fertilizer applied at time of planting.

This year there was a good stand and the vines made a good growth. It is doubtful if the soil condition had any marked influence on the results obtained from the spraying experiment.

The spray mixtures used were calcium arsenate, arsenate of lead, paris green and bordeaux mixture. The arsenate of lead was used

at the rate of 3 pounds of the powder to 50 gallons of water; the other insecticides were used in such proportions as to give equivalent amounts of metallic arsenic in every case. The insecticides were added in the experiment to determine the relative efficiency of the various sources of arsenic. This phase of the work was under the direction of the department of entomology of the station. The bordeaux mixture used was of the 5-5-50 formula, containing 3 pounds of arsenate of lead. *The sprays were applied with a power sprayer that* developed 250 pounds' pressure. As the field was laid out there were 25 plots, each 8 rows wide. A check plot alternated with each two treated plots. The check plots, nine in all, were sprayed with arsenate of lead. The paris green and calcium arsenate plots were repeated four times and the bordeaux plots eight times.

Table 3 records the dates on which the spray applications were made, as well as the insects and diseases present in the field at the time.

TABLE 3

Conditions of the Spray Applications

Plots	Date of Application	Insects Present	Diseases Present
5-11-17-23	May 16	Flea beetles	No foliage disease
All plots	May 27	Flea beetles	No foliage disease
All plots	June 5	Flea beetles	Some tip-burn
All plots	June 12	None	Tip-burn and early blight
All plots	June 20	None	Tip-burn and early blight

Prior to June 20 there were no noticeable differences between the different plots. After that date, the plots sprayed with paris green became heavily infested with early blight while the remaining plots were only slightly infested. Late in the summer the plots sprayed with arsenate of lead were decidedly better than those sprayed with bordeaux mixture. At first thought, this would appear to be due to the use of an improperly prepared bordeaux mixture. This explanation will not suffice, however, since plants under fertilizer and variety tests in adjoining fields were sprayed with the same mixture and on the sames dates. These vines remained green for some time after unsprayed plants in neighboring fields had begun to die. The fact that the plots sprayed with arsenate of lead were greener than the bordeaux plots would indicate that the former may have acted in some way to stimulate the vines. No definite statement to this effect can be made, however.

TABLE 4

Arrangement of Plots and Yields Per Acre in the Spraying Experiment With the American Giant Variety.

Section 1					Section 2					Section 3				
Treatment	All Plots	Calculated	Check	Difference	Treatment	All Plots	Calculated	Check	Difference	Treatment	All Plots	Calculated	Check	Difference
	bu.	bu.	bu.	per cent		bu.	bu.	bu.	per cent		bu.	bu.	bu.	per cent
Check	245.0	.....	.....	......	Check	273.1	.....	.....	......	Check	286.0	.....	.....	......
Bordeaux	188.3	230	123	—41.7	Bordeaux	229.1	264.0	115	—34.9	Bordeaux	265.1	285.0	107	—19.1
Calcium arsenate ...	188.3	215	114	—26.7	Calcium arsenate ...	207.3	255.1	123	—47.8	Calcium arsenate ...	207.3	284.1	137	—76.8
Check	200.0	.....	.....	......	Check	246.2	.....	.....	......	Check	283.2	.....	.....	......
Bordeaux	193.6	208.8	107	—15.2	Bordeaux	253.3	260.1	102	—6.8	Bordeaux	271.3	292.1	107	—20.8
Paris green ..	196.6	216.8	110	—20.2	Paris green ..	245.4	274.0	111	—28.6	Paris green ...	263.5	301.0	114	—37.5
Check	226.5	.....	.....	......	Check	287.8	.....	.....	......	Check	309.0	.....	.....	......
Bordeaux	188.3	226.5	120	—38.2	Bordeaux	220.0	284.5	129	—64.5	Bordeaux	237.9	303.6	127	—65.7
Calcium arsenate ...	233.3	226.5	97	6.8	Calcium arsenate ...	266.6	281.2	105	—14.6	Calcium arsenate ...	260.5	297.3	114	—36.8
Check	226.5	.....	.....	......	Check	277.9	.....	.....	......	Check	291.0	.....	.....	......

At harvesting time, most of the plots in the experiment were dug before the yields could be taken. As a result of this the yields on only ten plots were obtained. Each of these plots was divided into three sections in harvesting. In this way, three or more duplications of each treatment were secured. The arrangement of the plots together with the yields per acre are given in table 4.

It will be seen from the table that the yields of the bordeaux plots are lower than those of the arsenate of lead plots. The difference between the yields of the bordeaux, calcium-arsenate and paris-green plots is so small as to be well within experimental error. The average yields of the plots receiving the various treatments are summarized below:

Arsenate of lead	262.8 bushels per acre
Paris green	235.1 bushels per acre
Bordeaux mixture	228.3 bushels per acre
Calcium arsenate	227.2 bushels per acre

In connection with the tests of the different spray mixtures the experiment was designed to determine the most efficient pressure of applying the sprays. As has been previously indicated, there were four duplications of each spray treatment; two of these were applied at 150 pounds' and two at 250 pounds' pressure. Since the yields were not obtained from all the plots the results were incomplete, but those secured are given in table 5.

TABLE 5

Effect of Applying Sprays at Different Pressures

Treatment	Pressure	
	150 lbs.	250 lbs.
	bu. per acre	bu. per acre
Bordeaux mixture	215.7	227.5
Arsenate of lead	258.9	266.5
Calcium arsenate	253.4	200.9
Paris green	235.1	.....

The plots sprayed with bordeaux mixture at 250 pounds' pressure gave an increase of 11.8 bushels over those sprayed with 150 pounds. The results obtained with the insecticides are contradictory and no conclusions can be drawn from the data at hand.

An effort was made to determine if any benefit would follow an early application of bordeaux mixture. Four plots were sprayed with bordeaux when the plants were 6 inches high, and four others were sprayed when the plants were from 2 to 4 inches high. This early application was made in an effort to control flea beetles. When the plants are of this size, it is difficult to reach the lower leaf surface; this may account for the fact that very little control resulted. The average yield of the plots that received the early application was 17.8 bushels less than the yield of the plots where the early application was not made. No differences were observed between these plots during the summer, so there is no reason to believe that the plants were injured by the early application.

The conflicting results obtained from spraying the American Giant variety this year are in accord with those obtained in the experiments previously conducted with this variety. It is possible that varietal differences may be an important factor in potato spraying experiments. This would appear probable in view of the fact that most of the experiments with Cobblers conducted in past years have given positive results. The American Giant variety makes a rapid growth, soon filling the rows, making it impossible to continue the spray applications late in the growing season. While the results obtained this summer would not indicate this to be the reason for the lack of success in spraying this variety, it might help to account for it.

Late-Crop Spraying Test in Cooperation with J. Harry Kandle, Elmer, N. J.

The soil on which this test was conducted is a Sassafras loam in good condition. The field was without irregularities. The variety Irish Cobbler was planted. One ton of a 4-8-3 fertilizer was applied per acre at the time of planting, August 6. The field was divided into 19 plots, each 4 rows wide. The arrangement of the plots was such that a check plot alternated with each sprayed plot. There were no insects of any kind present so that it was possible to leave the check plots unsprayed. The treated plots were sprayed with bordeaux mixture, the 5-5-50 formnla being used.

Four spray applications were made. The first one, on September 12, was made when the plants were about 9 inches high; the delay in making the first application had no influence on the results, since there were no diseases present in the field at that time. At the time of the second application, September 19, there was a slight amount of early blight on the unsprayed plants. The third application was

made September 29. At this time, three plants infested with late blight were found in the check plots. At the time of the fourth application, October 9, 75 per cent of the leaves on the unsprayed plants were infested with late blight while there was only a trace on the sprayed plots.

A thorough examination of the field was made October 21, and at that time 3 per cent of the leaves on the sprayed plots were dead. The appearance of the check plots at this time was interesting. As has been stated, the plots were all 4 rows wide; in every case the plants in the two central rows of the check plots were dead. On the two outer rows, adjoining the sprayed plots, the inner half of the vines was dead while the side toward the sprayed plots was still green and vigorous. This was the result of some of the spray mixture reaching the outer side of the plants. In measuring the yields the outer rows of each plot were discarded.

TABLE 6

Arrangement of Plots and Yields per Acre of the Potato Spraying Test with Late-Crop Cobblers

Treatment	All Plots	Calculated Check	Difference
	bu.	bu.	bu.
1. Check	121.9	.....	....
2. Bordeaux	172.2	126.8	45.4
3. Check	131.8	.....	....
4. Bordeaux	190.1	126.2	63.9
5. Check	120.7	.....	....
6. Bordeaux	166.6	127.9	38.7
7. Check	135.1	.....	....
8. Bordeaux	185.0	138.0	47.0
9. Check	140.9	.....	....
10. Bordeaux	172.2	138.9	33.3
11. Check	136.9	.....	....
12. Bordeaux	196.2	138.9	57.3
13. Check	140.9	.....	....
14 Bordeaux	192.3	136.1	56.2
15. Check	134.7	.....	....
16. Bordeaux	195.1	135.8	59.3
17. Check	132.5	.....	....
18. Bordeaux	181.1	132.6	48.5
19. Check	131.9	.....	....

The treatments of the various plots together with the yields per acre are given in table 6. The average yield of the check plots was 132.6 bushels per acre and of the sprayed plots 183.4 bushels, a difference of 50.8 bushels in favor of the spray treatment.

Spraying experiments with the late-planted crop have given increases every year, even in the absence of late blight. This crop is planted late so that the vines will still be green when killed by frost, thus insuring seed of high vitality. This year a large part of the crop in South Jersey was dead for several weeks before frost, as a result of the epidemic of late blight. In this crop the yield is secondary in importance, the vitality of the tuber for seed purposes being the primary consideration. In view of this fact, the benefits to be derived from spraying the late crop cannot be measured by an increase in yield alone. While it is doubtless true that the differences obtained would not be as marked every year as they were this year, it is probable that spraying would hold the vines for some time. This consideration alone would possibly warrant the adopting of the practice of spraying the late crop.

SEED TREATMENT FOR THE CONTROL OF POTATO SCAB

WM. H. MARTIN

Seed treatment for the control of potato scab has been recommended for a number of years but the practice has not been generaly adopted in the important potato producing areas of the state. In some instances the omission of seed treatment is due to the fact that failure resulted from previous attempts. Where this occurred, it was largely due to the fact that the treated seed was planted in scab-infested soil. Under these conditions seed treatment will no doubt be of some value but will not insure a clean crop. In a small number of cases, injury has followed seed treatment; very frequently this has been due to the improper treatments, such as treating after the sprouts are well developed, employing too strong a mixture or allowing the tubers to remain too long in the solution and treating after cutting.

The principal reason for the failure to adopt seed treatment lies in the fact that the practice consumes so much time. The present recommendation for seed treatment is to soak the tubers for 1½ hours, which makes it practically impossible to treat the seed fast enough to keep ahead of the planter. This is especially true where a large acreage is planted; to treat enough seed for fifty or more acres would require the entire time of two men for several weeks at a time when they would be needed for other work.

Since the length of the time period has deterred the growers from treating seed, experiments were conducted to determine if this could be reduced without loss of efficiency. In connection with this, tests were conducted with both formaldehyde and mercuric chloride (corrosive sublimate) to determine which would give the best control of scab. The formaldehyde solution used was made up at the rate of

1 pint of 40 per cent formalin to 30 gallons of water; the mercuric chloride at the rate of 4 ounces to 30 gallons of water. In every case the solutions were used for only one lot of potatoes, when they were renewed. This was done to insure that all the solutions be of the same strength for the different treatments. In all there were four treatments as follows: 1 hour, ½ hour, ¼ hour and sprinkled. For the first three treatments, the different lots of potatoes were placed in wooden containers and covered with the solution to be tested. They were so left for the desired time period, and then were removed and dried. The potatoes that were sprinkled were placed in a heap and covered with a burlap bag for 30 minutes.

The seed used was a vigorous strain of home-grown Irish Cobblers. To insure the presence of the scab organism, scabby seed was planted, tubers being selected that showed approximately the same amount of scab. In cutting the seed, care was taken to have the seed pieces the same size, in order to eliminate differences that might arise from the use of seed pieces of different weight.

TABLE 1

Effect of Seed Treatment on Germination

Formaldehyde Treatment	Stand	Mercuric chloride Treatment	Stand
	per cent		per cent
1 hr.	98.4	1 hr.	98.0
½ hr.	98.8	½ hr.	96.8
¼ hr.	98.4	¼ hr.	98.8
Sprinkled	96.3	Sprinkled	97.2
Check	91.5	Check	91.5

The soil on which the experiment was conducted is a Penn loam in good condition. Sixteen hundred pounds of a 4-8-3 fertilizer per acre was applied at the time of planting, April 22. The field was divided into 24 plots, each 69 feet long and two rows wide, approximately one-fiftieth acre. These plots were laid out so that a check lot was left between each two treated plots, making eight in all. ach of the treatments was repeated twice.

13z June 2 a count was made of the number of plants up. The ence of this count are recorded in table 1, which gives the averages rent plots.

It will be seen from the table that the germination of the treated plots was practically the same. The average for the formaldehyde treatments was 97.9 per cent, and 97.7 per cent for those treated with mercuric chloride. The average for the check plots was 91.5 per cent. At the time of this observation, the plants on the treated plots were for the most part uniform in size while on the check plots some were up 6 inches and others had just appeared above the ground. The vines on the treated plots were larger throughout the early part of the summer than those on the untreated. As the season advanced this difference was not so marked.

TABLE 2

Effect on Yield and Scab Control of Treating Seed Tubers With Disinfectants

Treatment	Total Yield per Acre	Primes per Acre		Seconds per Acre		Unsalable Scabby per Acre		Scabby in Primes
	bu.	bu.	per cent	bu.	per cent	bu.	per cent	per cent
Formaldehyde 1 hour	147.4	134.7	91.3	8.2	5.6	4.5	3.0	18.4
Formaldehyde ½ hour	175.3	159.0	90.7	8.6	4.9	7.7	4.3	17.9
Formaldehyde ¼ hour	158.9	144.9	91.1	6.3	3.9	7.7	4.9	30.2
Formaldehyde sprinkled	146.4	130.9	89.4	8.2	5.7	7.3	4.8	29.9
Mercuric chloride.. 1 hour	178.6	159.0	89.2	11.9	6.5	7.7	4.2	17.2
Mercuric chloride.. ½ hour	148.3	131.5	88.6	8.2	5.6	8.6	5.7	26.6
Mercuric chloride.. ¼ hour	184.5	166.8	90.0	9.1	5.0	8.6	5.0	21.3
Mercuric chloride.. sprinkled	174.7	149.8	85.7	12.7	7.2	12.2	7.0	31.4
Check	145.6	117.8	80.9	10.3	7.2	17.5	11.8	43.9

Table 2 presents the yields of the different plots calculated as averages for the treatments. After the total yield for each plot was determined the tubers were sorted into three classes, namely, primes, seconds and unsalable scabby. The latter class was composed of tubers covered with the scab lesions. Tubers showing only a few lesions were included in the primes. A count was then made to determine the per cent of scabby tubers in the primes. It will be

seen from the table that the benefits derived from seed treatment are not to be measured by the control of scab alone, since an increase in total yield resulted from all the treatments. The average for the formaldehyde treatments shows a gain of 24.6 bushels per acre over the check plots. The average increase for the mercuric chloride treatments was 33.9 bushels per acre.

Summary

1. Untreated scabby tubers gave a low yield, 11.8 per cent of which were unsalable on account of scab. The salable tubers were of low grade, 13.9 per cent being scabby.

2. Scabby seed treated with either mercuric chloride (1 to 240) or formaldehyde (1 to 1000) gave a better stand than untreated scabby seed.

3. Soaking scabby seed in either of these solutions led to increased yields.

4. The formaldehyde treatment for ½ hour gave a greater increase of salable primes than the 1-hour treatment.

5. The mercuric-chloride treatment for ¼ hour gave a greater increase of salable primes than the 1 or ½-hour treatments.

6. The 1-hour treatment with either solution gave slightly better control of scab than the shorter treatments.

7. Soaking the seed for 15 minutes in either solution gave very good control of scab and a marked increase in salable primes over the check plots.

8. Sprinkling tubers with either formaldehyde or mercuric chloride not only reduced the amount of scab but increased the total yield, indicating that this method has some value.

THE INFLUENCE OF SULFUR ON SOIL ACIDITY AND THE CONTROL OF POTATO SCAB

Wm. H. Martin

The investigations on the control of potato scab conducted by H. C. Lint (3) in 1914, 1915 and 1916 were resumed this year.

While the results of previous experiments with the use of elemental sulfur for the control of scab have been contradictory, the evidence as a whole indicates the possibility of its use in this connection. In view of the fact that potato scab is becoming more and more destructive, it was thought advisable that further research be conducted on this problem. Since the presence or absence of the scab organism appears to be determined to a large extent by the soil reaction, in the work this year particular attention was given to the relation of

he organism to soil acidity as measured by the hydrogen-ion concentration and the relation of the latter to the amount of sulfur applied o the soil.

Experimental

During the summer of 1919, five field experiments were conducted. These experiments were performed on soil of different types, including sandy loam, Sassafras loam and Penn loam. In selecting the ields in which the experiments were conducted, care was taken to void any marked soil irregularities so that differences arising from oil variations might be reduced to a minimum. As an additional recaution check plots were left between every two treated plots and ach treatment was repeated at least three times. The size of the lots in the different experiments varied from 1/40 to 1/60 acre. Except for the sulfur treatments all the plots of an experiment were reated alike as regards fertilization and cultivation.

Sulfur was used in amounts varying from 300 to 1,200 pounds er acre. The sulfur used was the commercial flour sulfur. The applications were made broadcast after the land was harrowed and just efore planting. In one of the experiments the sulfur was applied y hand, in two others a lime distributor was employed while in the emaining two the applications were made with a grain drill. The atter method proved the most efficient, since the sulfur was thoroughly mixed with the surface soil and a more uniform distribution vas secured.

Experiments were conducted with the varieties American Giant and Irish Cobbler. When the potatoes were harvested they were separated into two classes, primes and seconds, the latter including all ubers under 1½ inches. The primes were then divided into classes depending on the degree of infection. In grading the primes of the American Giant variety, two classes were made, clean and scabby, the atter including all tubers showing any scab lesions. Three classes were made of the Irish Cobbler primes, namely, clean, salable scabby and unsalable scabby. The last class was made up of all tubers covered with the scab lesions, while tubers showing only a moderate infection were designated salable scabby. In this connection it must be stated that the percentage of salable scabby tubers in the primes s not a fair index of the actual control of scab since the salable scabby ubers from the check plots showed considerably more scab than those from the treated plots. This is particularly true of the American Giant variety; the primes in the sulfur-treated plots not only showed ess scab than those from the check plots but were of a much better color and texture.

Before making the sulfur applications soil samples were taken in the area to be included in the experiment and the hydrogen-ion concentration of water extracts of the soil samples determined colormetri-

cally following the work by Clark and Lubs (1) in the preparation of the buffer mixtures, the selection of suitable indicators and with general methods of procedure. When the crop was harvested, soil samples were taken in each plot and similar determinations were made. In taking the soil samples borings were made to a depth of 6½ inches, at intervals of 15 feet. These individual samples were then thoroughly mixed and a sample taken to represent the condition of the plot in question.

In preparing the water extracts of the soil samples to be tested a method was adopted which was essentially the same as that employed by Gillespie and Hurst (2). To 15 gm. of air-dry soil which had been passed through a 1-mm. sieve, was added 30 cc. of distilled water in a 100-cc. Erlenmyer flask. The flask was then shaken 75 times, when it was allowed to stand for a time period of 8 to 12 hours. The supernatant liquid was then drawn off and distributed to test tubes.

The yields per acre as well as the percentage of scabby tubers is presented in the following tables, in which the data given are averages obtained from at least three replications of each treatment and of six check plots. The yields of second-size tubers are included in the tables; in view of the fact, however, that the sulfur treatments appeared to have no influence on the number of seconds they will not be discussed.

Experiments with Cobblers

Experiment I

The soil on which this experiment was conducted is a sandy loam. In 1912, an application of lime was made at the rate of 1,200 pounds per acre; since that time succeeding potato crops have been severely scabbed. Soil samples taken before the sulfur applications were made showed a hydrogen-ion exponent of 6.15. Sulfur was applied at the rate of 400 and 600 pounds per acre. The effect of the sulfur in total yield and scab control is shown in table 1.

It will be seen from the table that with both the 400 and 600-pound applications there was a marked gain in the number of salable primes with a corresponding decrease in the number of tubers rendered unsalable by scab. In addition to this the per cent of scabby tubers in the salable primes was greatly reduced. It will also be observed that with the increased application of sulfur there was a decrease in exponent values of the soil extracts.

TABLE 1

Influence of Sulfur Applications on Total Yield. Per Cent of Scabby Tubers and Hydrogen-ion Concentration

Treatment per Acre	Total Yield per Acre	Yield of Primes			Yield of Seconds per Acre	pH Values of Soil Extracts
		Salable Clean per Acre	Scabby	Unsalable Scabby per Acre		
	bu.	bu.	per cent	bu.	bu.	
Check*	350.1	163.5	64.6	146.8	39.7	6.03
400 lbs. of Sulfur†	339.1	265.8	29.4	30.2	42.6	5.20
600 lbs. of Sulfur†	342.7	283.2	19.4	25.9	33.4	5.07

* Average of 6 plots.
† Average of 4 plots.

TABLE 2

Influence of Sulfur on Total Yield, Per Cent of Scabby Tubers and Hydrogen-ion Concentration

Treatment per Acre	Total Yield per Acre	Yield of Primes			Yield of Seconds per Acre	pH Values of Soil Extracts
		Salable Clean per Acre	Salable Scabby	Unsalable Scabby		
	bu.	bu.	per cent	bu.	bu.	
Check*	174.0	70.4	57.6	85.9	17.7	5.57
300 lbs. of Sulfur†	181.4	144.6	22.4	24.1	12.7	4.77
600 lbs. of Sulfur†	171.9	132.0	23.8	22.9	17.1	4.82

* Average of 6 plots.
† Average of 4 plots.

Experiment II

The soil on which this experiment was conducted is a heavier loam than that on which the first experiment was performed. Sulfur was applied at the rate of 300 and 600 pounds per acre. The results of the sulfur treatment are given in table 2. As in the preceding experiment there was a marked reduction in the yield of unsalable scabby tubers on the treated plots, leading to an increase in the number of salable primes. The plots receiving 300 pounds of sulfur showed an increase in total yield, while the plots treated with 400 pounds of sulfur per acre showed a slight decrease. The differences in either case are small, however, and it is doubtful whether any importance can be attached to them. The initial hydrogen-ion exponent of this soil was 5.6 as compared with 5.57 for the check plots at the time of harvesting. A marked decrease in exponents resulted in the plots receiving the sulfur applications.

TABLE 3

Influence of Sulfur Applications on Total Yield, Per Cent of Scabby Tubers and Hydrogen-ion Concentration

Treatment per Acre	Total Yield per Acre	Yield of Primes: Clean per Acre	Yield of Primes: Scabby	Yield of Seconds per Acre	pH Values of Soil Extracts
	bu.	bu.	per cent	bu.	
Check*	144.3	128.4	60.0	14.7	6.27
300 lbs. of Sulfur†	147.0	135.4	43.6	11.6	5.90
600 lbs. of Sulfur†	134.4	119.4	26.9	15.0	5.83
900 lbs. of Sulfur†	156.2	141.8	26.3	14.1	5.13
1200 lbs. of Sulfur†	156.6	142.5	15.7	14.1	5.10

* Average of 8 plots.
† Average of 3 plots.

Experiment III

The soil on which this experiment was conducted is a Penn loam that had not been planted in potatoes for a number of years. To insure the presence of the scab organism in the soil, scabby seed was planted. Sulfur applications were made at the rate of 300, 600, 900 and 1,200 pounds per acre. The results of this experiment are given in table 3.

On the basis of total yield the plots treated with sulfur at the rate of 600 pounds per acre showed a decrease of 9.9 bushels per acre as compared with the check plots. Each of the other plots showed an increase in yield. This increase was 2.7 bushels, 11.9 bushels and 12.3 bushels per acre for the plots treated with 300, 900 and 1,200 pounds of sulfur, respectively. In this experiment no tubers were rendered unsalable by scab. From table 3 it will be observed that the per cent of scabby tubers in the primes decreased with the increased sulfur applications, the plots receiving the highest sulfur application yielding the lowest per cent of scabby tubers. With the increased application of sulfur there was a corresponding decrease in hydrogen-ion exponent values, the plots receiving the 1,200-pound treatment showing the lowest values and the lowest per cent (15.7) of scabby tubers among the primes.

Experiments with the American Giant Variety

Experiment I

The soil on which this experiment was conducted is a heavy loam that had produced severely scabbed potatoes the preceding year. Sulfur was applied at the rate of 300 and 400 pounds per acre. The results of the experiment are given in table 4. On the basis of total yield, the treated plots showed an increase over the untreated check plots, this increase amounting to 20.5 bushels per acre for the 300-pound treatments and 5.8 bushels per acre for the 600-pound treatments. From table 4 it will be seen that the per cent of scabby tubers in the primes was greatly reduced by the sulfur treatments. Of the total yield of prime tubers from untreated plots, 82 per cent were diseased while the plots treated with 300 pounds of sulfur per acre and those receiving the 400-pound treatment gave total yields of primes of which only 23.6 per cent and 15.8 per cent, respectively, were scabby.

The initial hydrogen-ion exponent value of soil extracts was 5.6 at the time of harvesting, average hydrogen-ion exponent value of soil samples from the check plots at time of digging was 5.55. It will thus be observed from table 4 that with each decrease in the value of the hydrogen-ion exponents below that of the check plots, a

corresponding decrease occurred in the per cent of scabby tubers among the primes.

TABLE 4

Influence of Sulfur Applications on Total Yield, Per Cent of Scabby Tubers and Hydrogen-ion Concentration

Treatment per Acre	Total Yield per Acre	Yield of Primes: Clean per Acre	Yield of Primes: Scabby	Seconds per Acre	pH Values of Soil Extracts
	bu.	bu.	per cent	bu.	
Check*	280.8	240.8	82.0	40.0	5.55
300 lbs. of Sulfur†	301.3	247.7	23.6	53.6	5.07
400 lbs. of Sulfur†	286.6	247.7	15.8	38.9	4.90

* Average of 6 plots.
† Average of 4 plots.

Experiment II

This experiment was conducted on a light sandy loam soil underlaid at a shallow depth by a greensand marl. In 1918 potatoes grown in the field had been severely scabbed. Sulfur was applied at the rate of 500 and 700 pounds per acre. The results are presented in table 5. The data of this table indicate a reduction of 44.8 bushels per acre for the plots treated with 500 pounds of sulfur in comparison with the corresponding yields from the check plots. It is questionable, however, whether this decrease in yield can be ascribed to the sulfur treatment, since the plots receiving the 700-pound application gave an increase of 3.5 bushels per acre over the yields from the check plots. A much lower percentage of scabby tubers was obtained from the treated than from the untreated plots. This decrease in the percentage of scabby tubers was much more pronounced than is apparent from the figures given in the table since the tubers from the treated plots classified as scabby showed fewer lesions than did those from the check plots.

In this experiment the amount of scab on the tubers from the treated plots was reduced to only a few lesions. It is doubtful whether scab could be entirely eliminated from the crop even by heavier applications of sulfur, since the exponent values resulting

from the 400 and 700-pound applications are considerably lower than the exponent shown in Gillespie (2) to inhibit the growth of the scab organism in culture media.

TABLE 5

Influence of Sulfur Applications on Total Yield, Per Cent of Scabby Tubers and Hydrogen-ion Concentration

Treatment per Acre	Total Yield per Acre	Yield of Primes		Yield of Seconds per Acre	pH Values of Soil Extracts
		Clean per Acre	Scabby		
	bu.	bu.	per cent	bu.	
Check*	247.3	184.4	64.4	62.8	5.6
500 lbs. of Sulfur†	202.5	161.2	28.8	41.3	4.8
700 lbs. of Sulfur†	250.8	191.6	23.8	59.1	4.8

* Average of 6 plots.
† Average of 4 plots.

Summary

With due regard for the limitations of the experiments here reported, resulting from the fact that they were conducted for one year only, the following points may be advanced.

1. With the different amounts of sulfur used, all gave substantial gains in the number of clean tubers. With the heaviest application, however, scab was not entirely eliminated.

2. The results would indicate that with those varieties of potatoes known to scab severely, the use of sulfur in the proper amount will render a large portion of the crop salable.

3. In all cases, following applications of sulfur, there was an increase in soil acidity as measured by the hydrogen-ion concentration of soil extracts. In most instances this increase in acidity, corresponding to a decrease in hydrogen-ion exponent, was in proportion to the amount of sulfur applied.

4. With a decrease in hydrogen-ion exponent there was a decrease in the number of scabby tubers.

5. The necessity of knowing the soil reaction before sulfur applications are made, is evident from the fact that where the hydrogen-ion concentration of water extracts of soil samples was 5,800 less, the lighter applications (300 to 500 pounds), gave approximately as good

control of scab as the heavier applications (700 to 1,200 pounds). Where the initial exponent was greater than 6.0 the heavier applications gave best control.

6. The results of the present work would indicate that the limiting exponent for the growth of the scab organism is lower in soil than in culture media.

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REPORT OF CORN ROOT AND STALK ROT INVESTIGATIONS, 1919

I. C. HOFFMAN

Indiana Agricultural Experiment Station

in cooperation with

M. T. COOK

The experimental project in New Jersey was organized in cooperation with Dr. M. T. Cook, plant pathologist of the New Jersey Agricultural Experiment Station, and the plot was placed on the College Farm. The object of the experiment was to study the field performance of disease-free and diseased ears as determined by the germination test.

The seed was selected from New Jersey-grown stock at the instance of Dr. Cook and sent to Bloomington, Illinois, where it was germinated and examined by J. R. Holbert. From these ears enough were selected to form an ear-to-row plot of 99 rows. Enough corn was shelled and pocketed from each ear to plant a row. Whatever remnant ears were left were cared for by Mr. Holbert.

For the most part the rows were alternated between disease-free and diseased seed. It was not possible to carry out this plan of arrangement entirely on account of the limited number of ears available. The majority of the ears selected were run in duplicate, while a few others were added to the plot for special studies.

The spot selected for the plot was in the middle of a 7-acre field which was planted to the same kind of corn. At the north and south

ends of the field were patches of standing timber. A hedge of trees and shrubs connected these patches of timber on the west side of the field containing the plot, while four or five large trees stood along the east edge. In this manner the field was protected from high winds which tend to blow the stalks over.

The soil was a retentive loam which was very full of small pebbles and stones. It would probably be classed as a gravelly soil. It differed from the usual gravelly type in that it retained moisture usually well. The land sloped gently to the north and east with the highest part in the southwest quarter. However, the difference in elevation was slight.

The field consisted of an old timothy sod from which a crop of hay was taken in 1917 and 1918, as well as some previous to these seasons. In 1918 it was top-dressed with 300 pounds of acid phosphate and 100 pounds of sodium nitrate per acre. It was probably fertilized with a like amount in 1917, but positive information was not available. In 1919, at the time of plowing and preparing the seed-bed, 8 tons of manure and 450 pounds of acid phosphate and ammonium sulfate in the proportion of 3 to 1 by weight were applied per acre. The soil was plowed deep and harrowed thoroughly. The preparation of the seed-bed was done under the direction of the farm foreman, and labor for planting the plot was furnished by him.

Because of so much rain the planting had to be delayed until May 20 and 21. At this time the entire field was scored in both directions and the boundary of the plot marked by stakes. The rows contained 50 hills each, with 3 kernels of corn per hill. The kernels were placed in the hill by hand and were arranged in the position of an equilateral triangle to afford space for early growth and also to make a uniform type of hill for comparing the growth of the plants. This type of hill also lessened the danger of injury to the plants during cultivation. The kernels were covered with loose soil to a depth of 1 to 1½ inches. The covering also was done by hand to insure uniformity. The surrounding corn was planted with stab planters.

The corn seedlings came up between May 26 and 28, and on June 13 the first notes were taken on stand and vigor of the plants. On the same day, cultivation was begun and the first cultivation was completed on June 14. In all, three cultivations were given the plot during the season. More should have been given but it became impossible because of the lack of farm labor.

At the time of taking the first notes the plants were about the same size. They had become established and their roots were spreading in the soil. Evidence of disease was showing in occasional plants as indicated by lack of color and size. While the difference in size was not great, it was, however, sufficient to detect the strong, medium and weak plants. In several cases, the seed for planting certain rows was taken from ears which showed a large amount of infection with the ear rots. Rows 10, 17, 33 and 37 are examples of this,

and the effect on the original stand is very marked. Row 10 has 63 plants; no. 17 has 16; no. 33 has 89, and no. 37 only 9. In each of these rows the plants were very uneven in size and irregular in color.

A close examination of the ears from which the seed for each row was taken showed a marked difference in composition. The range ran from medium starchy, through various grades to very horny. Two classes, starchy and horny, were established based upon this factor, and the studies following will partially be based upon this condition in comparison with the disease character.

At the time the first examination of the plots was made the total stand was counted and a record taken of the strong, medium and weak plants in each row. Table 1 shows the correlation of initial stand to disease-free and diseased ears.

TABLE 1

Initial Stand June, 1919

Group	No. of Rows	Total Stand	Strong	Medium	Weak
		per cent	per cent	per cent	per cent
Disease-free	78	94.6	94.3	3.5	2.2
Ears with scutellum discolored	8	80.6	90.9	4.9	2.4
Diseased	11	79.3	84.0	9.2	5.8

The data here presented show that the disease-free ears gave a larger total per cent of initial stand and also a greater per cent of strong plants than those of the other groups. Consequently there were less medium and weak plants produced. The group with ears containing discolored scutellums, which were suspected of being diseased, produced an average stand of 80.6 per cent with a larger percentage of strong and fewer medium and weak plants than the diseased ears, but the stand and the vigor were somewhat less than those in the disease-free group.

Table 2 is a correlation between initial stand and composition in disease-free and diseased ears. The starchy corn produced a larger stand with a larger per cent of strong plants than the horny type in the disease-free group. In the groups of ears showing seedlings with discolored scutellums and disease, the larger stands were produced in the horny type while the largest percentages of strong plants came in the starchy type of seed.

In August the final counts for stand were made, as shown in table 3. The corn plants were practically full-sized and the ears had just been pollinated. As in the first count the disease-free corn maintained a decided increase in total stand over the other groups. The per cent of strong plants was decidedly greater and the percentages of medium and weak plants were significantly smaller than those in the diseased ears, respectively.

TABLE 2

Composition in Relation to Initial Stand, June, 1919

Composition	Disease-free Ears				Ears with seedlings showing discolored Scutellums				Diseased Ears			
	No. of Rows	Initial Stand	Strong Plants	Per cent Strong	No. of Rows	Initial Stand	Strong Plants	Per cent Strong	No. of Rows	Initial Stand	Strong Plants	Per cent Strong
Starchy	45	143	136	95.1	4	112	104	92.8	4	114	99	86.8
Horny	33	141	133	94.3	4	128	117	91.4	7	121	99	81.8

TABLE 3

Final Stand, August, 1919

Group	No. of Rows	Total Stand	Strong	Medium	Weak
		per cent	per cent	per cent	per cent
Disease-free	78	92.6	91.3	4.2	5.0
Ears with scutellum discolored	8	77.3	93.0	0.8	6.0
Diseased	11	76.0	77.1	11.4	12.2

Ears showing seedlings with discolored scutellums had a much smaller stand than the disease-free ears, and slightly greater than those from diseased ears.

The differences between the stands of the disease-free and diseas rows at the beginning and the close of the season remained relative the same, indicating that when the plants of disease-free or diseas seed are once established in the soil, both classes are subjected large to the same influences that effect mortality.

In comparing the effect of the composition on the stand in rov planted with disease-free and diseased seed at the end of the seaso it is observed in table 4 that the same facts hold that were found the beginning of the season. The starchy corn produced a great stand than the horny ears. The total number of plants from th horny diseased type is considerably reduced in comparison with th same type from the disease-free seed, and the number of strong plan is large in proportion to the total stand.

TABLE 4

Composition in Relation to Final Stand, August, 1919

Composition	Disease-free Ears				Ears with seedlings showing discolored Scutellums				Diseased Ears			
	No. of Rows	Final Stand	Strong Plants	Per cent Strong	No. of Rows	Final Stand	Strong Plants	Per cent Strong	No. of Rows	Final Stand	Strong Plants	Per cent Strong
Starchy	45	140	132	94.3	4	107	100	93.4	4	112	97	86.
Horny	33	138	119	86.2	4	125	122	97.6	7	116	83	71.

The group of ears with seedlings showing discolored scutellum varied somewhat during the season. The horny type of kernels main tained a larger stand and also attained a higher per cent of stron plants, whereas the starchy type had a larger per cent of strong plant at the time the initial count was made. The horny type in this cas had a smaller stand than either group in the disease-free ears, an larger than the same groups from the diseased ears. The starch corn in this same group produced the lowest stand of any group, bu ranked third in per cent of strong plants. All of this indicates tha for conditions obtaining at New Brunswick, the disease-free ears o the medium starchy type will produce the greatest total stand an the largest number of strong plants.

Progress of the diseases on the young corn plants was observed b the characteristic chlorosis and wilting effects. In the worst case

they resulted in blighting and death to the plants. In others, the plants were sufficiently resistant to the disease so that they grew slowly and produced what were classed also as medium and weak plants. Plants that started out as medium and weak ones usually remained as such, except as a medium plant would become weak, or a weak one die through the progress of the disease.

Later, when the stalks were about full grown, an index to the root development was given through the numbers of broken and down stalks. Just before harvest time, this condition was at its worst. The leaning, broken and down stalks were not confined to definite rows but were generally found in the entire plot. The stalks did not lie in a single direction as if a high wind had blown them over, but they seemed to fall in all directions, leaving the plot in bad condition for harvesting. From what is known of the effect of root development on the ability of corn to stand up, it appears that the root systems of the plants in this soil were badly infested. However, no examinations were made so no conclusions can be drawn.

TABLE 5

Composition in Relation to Yield, 1919

Composition	Disease-Free Ears		Ears with Seedlings Showing Discolored Scutellums		Diseased Ears	
	No. of Rows	Yield	No. of Rows	Yield	No. of Rows	Yield
		bu.		bu.		bu.
Starchy	45	76.05	4	73.48	4	55.73
Horny	33	67.07	4	71.00	7	50.98

The corn surrounding the plot was cut and shocked when it was sufficiently matured. The plot was left uncut and allowed to ripen as normally as possible. Labor for husking and storing the crop was furnished by Dr. Cook and the farm manager. As soon as the corn had dried sufficiently the ears were husked from the uncut stalks and carried in baskets to the east end of the rows and piled separately. The yield of each row was then weighed accurately on platform scales and the weights recorded, after which the corn was turned over to the farm manager.

Three sets of comparisons are presented with respect to composition and disease characters.

The yield of starchy corn is 8.98 bushels per acre larger than that of the horny corn in the disease-free group. It was 2.48 bushels greater in the group of ears showing seedlings with discolored scutellums, and 4.75 bushels greater in the diseased group of horny seed. The starchy disease-free group yielded more than any other group and the horny diseased group yielded the least.

TABLE 6

Yield Data, October, 1919

Row No.	Yield Per Acre	Row No.	Yield Per Acre	Row No.	Yield Per Acre
	bu.		bu.		bu.
1	67.13	34	70.21	67	89.92
2	81.29	35 SD	77.15	68	82.45
3	60.51	36	84.68	69	78.22
4	52.19	37 D (out)	5.23	70	66.50
5	51.27	38	92.53	71	66.67
6	63.74	39 SD	66.05	72	83.30
7	64.20	40	80.99	73	74.98
8 D	50.81	41 D	64.67	74	82.37
9	60.51	42	74.06	75	86.53
10 D	25.25	43 D	59.12	76	70.82
11	51.73	44	67.13	77	62.36
12 D	49.88	45	52.88	78	67.44
13	54.50	46 SD	79.14	79	67.90
14	58.20	47	72.21	80	73.13
15	50.81	48	79.89	81	85.53
16	53.58	49	82.79	82 SD	68.95
17 D (out)	3.38	50	77.29	83	81.91
18	62.86	51	66.20	84	74.06
19 D	43.26	52	81.91	85	103.31
20	63.74	53	57.13	86 SD	66.97
21	90.38	54	75.29	87	65.59
22	50.81	55	86.53	88	80.52
23 D	53.58	56 SD	73.13	89	60.05
24	45.26	57	72.60	90	80.52
25	59.12	58	74.98	91	68.98
26	65.13	59	85.14	92	91.15
27 SD	71.59	60 SD	74.98	93	62.05
28	70.82	61	68.98	94	87.30
29 D	60.42	62	74.98	95	79.14
30	66.50	63	69.44	96	72.60
31 D	71.59	64	87.45	97	94.07
32	63.74	65	66.67	98	82.37
33 D	48.96	66	70.36	99	74.98

SD—Scutellum discolored

FUNGI INJURIOUS TO PAINTS

C. M. HAENSELER

Studies on fungi injurious to paints were begun in July, 1916, and carried on until September, 1917, at which time the writer entered military service. The studies were resumed again in September, 1919, and are still in progress.

The problem was considered in a very general way and an attempt was made to make a survey of the field as a whole, rather than to undertake an exhaustive study of any particular phase. Attempts were made through observations and experimental studies to throw light on the following:

1. The prevalence and economic importance of fungous injury to paints.
2. The species of fungi causing the injury.
3. The nature of the injury.
4. The source of food for these fungi.
5. The environmental conditions necessary for their development.
6. The relative growth of fungi on paints of various composition and on paints applied to various woods.
7. Possible control measures.

Fungi growing on painted and varnished surfaces have been found to be very generally distributed and of much more common occurrence than heretofore has been suspected. They are found abundantly both on exterior and interior painted surfaces, wherever the proper conditions are presented.

It is difficult to get even an estimate as to the economic importance of these paint-inhabiting fungi. Apparently the only direct reference which is printed concerning losses of paint due directly to fungi, is given by Massee (2), who states that in one case a number of newly painted greenhouses had to be repainted on account of a severe reddening of the wet paint due to the presence of a fungus growth. Such a complete ruination of a freshly applied paint is doubtless very rare. The greater injury is caused by the blackening and mottling of white painted surfaces after a considerable length of time. In such cases the surface finally becomes so unsightly that a new aplication of paint must be made on account of the appearance, long before the old coat has lost its real protective power.

The species of fungi found on painted surfaces are quite numerous but the forms which are constantly associated with paint discoloration are relatively few. Such forms as *Alternaria, Aspergillus, Penicilium, Sporotrichum* and variuos yeasts and bacteria are frequently gotten in petri-dish cultures from discolored paint surfaces but these forms are usually not the cause of the discoloration. In certain cases *Aspergillus* and *Penicilium* have been found to be the principal fungi present and the sole cause of the discoloration, but they have not been found to be very prevalent. Bacteria and yeast are found only on very moist surfaces and are unimportant in connection with these studies.

Dematium pullulans DeB. & L., several species of *Cladosporium*, two species of *Phoma* and an unidentified fungus with a red-brown mycelium have been found to be the important species causing discoloration on painted surfaces. *Cladosporium* and *Aspergillus* have been found causing considerable injury to varnished surfaces.

Each species causes a specific type of spotting or discoloration, and as a rule, the species of the fungus can be determined from the characteristics of the colonies and the color produced on the underlying paint.

The discoloration of the paints may be due to the presence of black or brown hyphæ or resting bodies (*Dematium*, *Cladosporium*, *Phoma* sp.), or to the presence of masses of highly colored spore masses (*Aspergillus*, *Penicilium*), or to the production by the fungus of soluble pigments which discolor the paint itself (*Phoma pigmentivora*). Discoloration varies, with the species, from a very uniform darkening of the entire surface (*Dematium*) to small black specks (*Cladosporium*) or to large irregular red, or reddish brown blotches (*Phoma* sp.).

Careful observations and experiments have been made to determine the source of food of the paint-inhabiting fungi. A series of experiments were made to test the ability of the various fungi to use linseed oil as a food. None of the fungi were able to derive their full nourishment from the oil. In agar containing nutrient salts, however, they were able to break down the oil and utilize it as a source of carbon. Panel tests seem to indicate that the fungi are unable to make an appreciable growth on perfectly clean painted surfaces. A very small amount of nourishment added to the surface allows a considerable growth. Whether or not the fungi are able to attack the oxidized oil film and utilize this as a source of energy has not been determined definitely. Observations and experiments seen to indicate that, as a general rule, the fungi which grow on painted surfaces, especially those which produce colonies, derive their nourishment from foreign matter which happens to be on the paint, but that in certain cases it seems probable that they may utilize the oil of the paint or its disintegration products as a source of energy.

The environmental conditions to a very large extent control the presence of fungi on paints. In greenhouses with relatively high temperature and humidity these fungi are most prevalent. Even in the greenhouse certain species are very localized on account of the favorable environments at certain points. Other species, such as *Dematium pullulans*, are very indifferent and may grow luxuriantly either on moist or dry interior surfaces or on exposed exterior surfaces.

A large number of panel tests have been conducted to determine the relative growth of fungi on the various types of paint. White lead (carbonate), white lead (sulfate), zinc oxide, lithopone, a mixed paint (50 per cent lead, 50 per cent zinc) and a ready-mixed commercial paint were included in the tests. Some of these panels were exposed to the atmosphere and natural infection in greenhouses;

other small panels were inoculated with pure cultures and exposed in aerated moist chambers. Some of the tests were made by applying the paints directly to the interior wood and steel work of a greenhouse. The panels have been exposed for from 6 months to 3 years, the majority of the panels still being under observation. The greenhouse and laboratory panels, as well as general observations, show that lithopone is readily subject to fungus attack. Even after 6 months' exposure lithopone showed very severe blackening due to fungi. Next to lithopone, pure white lead (carbonate) is the most subject to attack. The pure lead panels in all cases showed severe blackening and spotting due to fungi, while zinc oxide and mixed paints showed only occasional colonies.

Culture tests were made to test the relative toxicity of lead carbonate, lead sulfate and zinc oxide pigments. Lead carbonate proved to be the least toxic. Zinc oxide was the most toxic to some of the fungi, lead sulfate to others. The fungi were able to grow in the presence of large amounts of all of these pigments.

Tests to determine whether the purity of the linseed oil used in mixing paints affected the fungus growth on these paints failed to show any noticeable difference between ordinary linseed oil and a special purified grade.

White pine, spruce and cypress panels, when painted with the same paint, all developed fungi alike. The different woods did not affect the kind or amount of growth.

A series of panel experiments were conducted to determine the possibility of preventing the growth of fungi on paints by means of adding various antiseptics and poisons to the paints before application. One per cent by weight of copper sulfate, 4 per cent of benzol and 2 per cent of mercuric chloride, zinc chloride, carbolic acid and toluene, respectively, were added to the second coat of paint before application. All of these treated paints developed a good growth of fungi. *Dematium* and *Cladosporium* developed on all the paints alike. The *Phoma* sp. and the red-brown unidentified fungus seem to be more sensitive to the antiseptics. These species were found to have somewhat less growth on paints treated with copper sulfate and mercuric chloride. Although Massee (2) and Gardner (1) have recommended antiseptics as a control for fungi on paints these tests seem to indicate that antiseptics and fungicides added directly to the paints are not especially effective.

The studies on fungi injurious to paints are still in progress. The laboratory tests and greenhouse panels will be continued for at least another year before a final report is made.

References

(1) GARDNER, H. A., 1913. Notes on the formation and inhibition of mildew in paints. *In* Jour. Franklin Inst., Jan. 1913, p. 59-64.

(2) MASSEE, G., 1911. A new paint destroying fungus. *In* Roy. Gard. Kew, Bul. Misc. Inform., no. 8 (1911), p. 325-326.

CELERY DISEASE INVESTIGATIONS

ROBERT F. POOLE

Experiments conducted by W. S. Krout in 1916 and by the writer in 1917 in the Oradell-Ridgewood region of Bergen County have in part been continued. Some of the chemical disinfectants applied to the diseased areas have been eliminated, because toxicity resulted in some cases without control of the diseases. Other compounds which gave promise of control were applied this season in greater amounts. Data to be collected during the summer may warrant recommending positive or negative results so far as applying chemical compounds to the soil for the control of the soft rot organism is concerned. We are more interested in controlling the disease from a practical standpoint, which interests the farmer. Sterilizing the greenhouse beds with steam or formalin is a valuable asset to every farmer, and when properly applied, damping-off and root-rot diseases are readily controlled in the seed-beds. Hardy green celery varieties have never been as susceptible as the golden self-blanching varieties. In the past few years, however, a great many diseased plants of the green varieties have been seen in the field. The symptoms are the same in all respects as those of the yellow varieties. The bacterial disease has spread to most of the muck-soil farms. Temperature is a great factor because golden self-blanching varieties grow well on diseased muck lands from April to July. After this period, growing golden self-blanching celery results in a complete failure on infected muck soils.

Copper sulfate, ferrous sulfate, hydrochloric acid, potash, phosphoric acid, lime, sulfur, cyanamide and other compounds were applied to the infected land this season in various amounts to determine their effect as disease controls.

Seedling plants were treated in mercuric chloride, 1 to 1,000, for 3 and 5 minutes. Some of the former lived, but even this short exposure was too great for the tender roots and the plants grew very slowly. A copper sulfate solution, 1 pound to 50 gallons of water, gave similar results, but further treatment of this nature was discontinued because of toxicity and stunting of plant growth. Weaker solutions of these disinfectants could not be depended on to control the organism.

Transplanting may prove beneficial; however, plants grown at the Experiment Station in sterilized sandy loam, became diseased in a few cases when grown in infected muck soil. Further trials of transplantings may be worth while.

Very vigorous strains of golden self-blanching celery growing in diseased areas have encouraged breeding for strains resistant to the root rots. Forty mature stalks of celery collected from the diseased

areas were transplanted from the fields into the plant pathology greenhouse at the Experiment Station in November, 1919. Practically all of the plants grew well for a few weeks, some for 4 months. High temperature and high humidity late in November developed and the dormant organism became active to such an extent that 25 of these stalks died in one week by decaying in the heart. Ten more of the plants died in the latter part of March, 1920. Five of the 40 plants selected showed no sign of disease during the winter. Of the seed that formed, some was distributed for quick trial among several of the best celery growers of Bergen County on June 23. This seed will be given a better test next year. If infestation becomes very serious on green celery varieties, strong strains of these varieties will be selected for seed. Celery seeds more than three years old germinate poorly. The vitality of golden self-blanching celery seed is poor in comparison with that of the green celery varieties. From this standpoint alone, we cannot lay too much emphasis on advantages gained by selecting stalks which will produce the very best of seed. Every grower of celery should take pride in growing seed from his own stock, which will give strong plants to begin with.

The organism causing celery root rot has been isolated. Numerous infection experiments have proven its pathogenicity. Green celery varieties and other vegetables have been inoculated with the organism with success. High humidity with a temperature above 80° F, is most favorable for developing soft rots caused by this organism. The number of this organism, following the outline formulated by the Society of American Bacteriologists is 221–1,113,523. Wormwald (2) described an organism with this same number and named it *Bacillus apiovorous*. *Bacillus carotovorous* Jones (1) is perhaps the same organism, or they are two of many strains of a bacillus which produces soft rots of vegetables and other foods. The only contrast between the two organisms as compared by Wormald was a few minor differences of growth in synthetic culture media and the fact that his organism produced yellow chromogens. *Bacillus carotovorus*, on the other hand, was described by Jones as non-chromogenic. The organism isolated is very variable in results unless it is kept revigorated. Carrots became diseased on the diseased muck soil as severely as golden self-blanching celery, and no distinction could be made from the organisms isolated from the celery and carrots. We doubt, therefore, whether even strains of this soft rot bacillus should be given as different species. Experiments have shown that the character of rot symptoms is due entirely to the physiological conditions of both host and parasite.

References

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(2) WORMALD, H., 1913. A heart rot of celery caused by bacteria. *In* Jour. Southeast. Agr. Col. Wye, no. 22 (1913), p. 457-473.

17 JUN 1936

HORSE-RADISH ROOT ROT INVESTIGATIONS

ROBERT F. POOLE

In the past few years much horse-radish root rot has been reported from Passaic County. The annual losses, however, do not exceed 2 per cent. The cause of the disease is a bacterium. The disease occurs in a general way, well distributed in the field. Historic facts concerning the disease are more or less conflicting. Some of the older growers claim that they have detected the horse-radish root rot for many years in their fields. Other growers claim that the disease was introduced in the past 4 or 5 years.

The symptoms of the horse-radish root rot are most pronounced about harvest time. The rot is confined to the core of large roots. Rarely if ever is the outer wall attacked. Unless the growers keep the head roots stripped off, there is no way of estimating the amount of diseased roots in a field. The head root system would keep the plant in a growing state even though the main root was decaying. If the head roots are stripped back and the root is infected, wilting and death will result on drying hot days. The rate of transpiration would be too great for the diseased end roots. If one end of a root is badly diseased when it is planted, decay is encouraged by rodents, saprophtic fungi and bacteria. Rodents eat through the outer walls of the roots and soft decay sets in. The interior of a horse-radish root shows a distinct line of demarkation. An outer zone of healthy tissue encloses a core of decaying, water-soaked tissue which is yellowish in color and contains great numbers of bacteria. In older roots a distinct slackening occurs and very old roots become hollow. The horse-radish root is a good medium for the growth of both bacteria and fungi.

Rhizoctonia sp., *Penicillium* sp., *Thielavia basicola* and *Rhizopus* sp., have been constantly isolated from specimens of horse-radish sent to the laboratory and also from many diseased roots found during seed selection. Some of these fungi are known to cause rots of sweet potatoes and other root crops in storage and their relation to the horse-radish rots will be studied in the future.

The general nature of the disease leads us to believe that the disease is present in the horse-radish roots when they are set in the field. Mr. Fisher, a Passaic County farmer, has agreed to cooperate with us in this work. Mr. Wettyen, county agent of Passaic County, also has assisted us in starting the investigation of horse-radish diseases. Experiments are being carried on along the following lines:

1. Selection of disease-free roots for planting.
2. Disinfecting roots with formaldehyde and corrosive sublimate.
3. The effects of acid and alkali soils on the organism.
4. Better methods of storing seed-roots over winter.

The systematic nomenclature of the organism is being studied. It

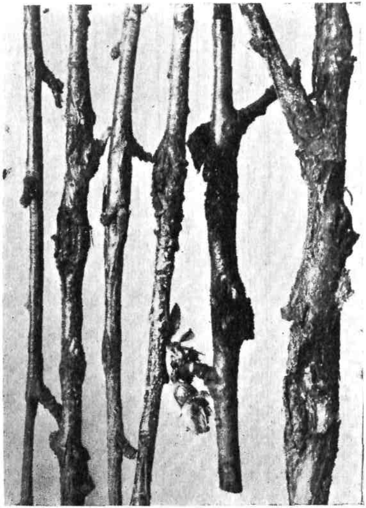


Fig. 1. Brown rot of peach showing infected twigs

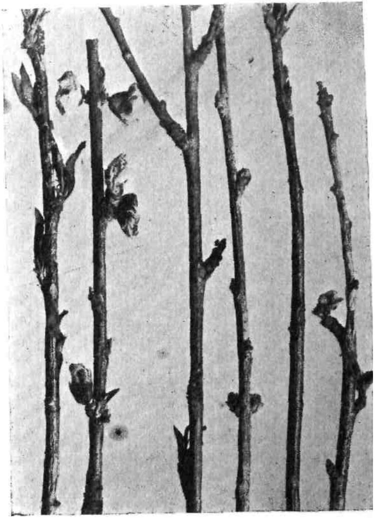


Fig. 2. Brown rot of peach showing infected twigs

PLATE 2

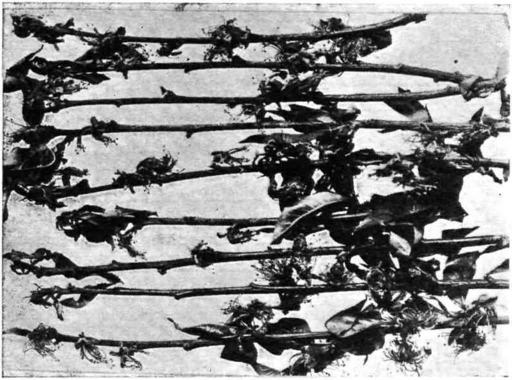


FIG. 1. Brown rot of peach showing infected blossoms and foliage

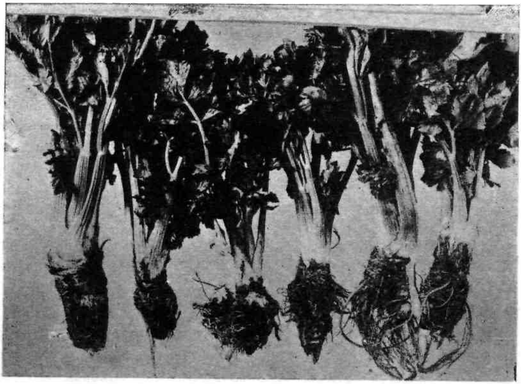


FIG. 2. Root rot of celery

PLATE 3

FIG. 1. Late blight of celery. Photo taken immediately after the first frost, killing all the leaves that were infected. Killed leaves drooping over edge of boards

FIG. 2. Close view of plants infected with late blight (*Cercospora apii*)

PLATE 4

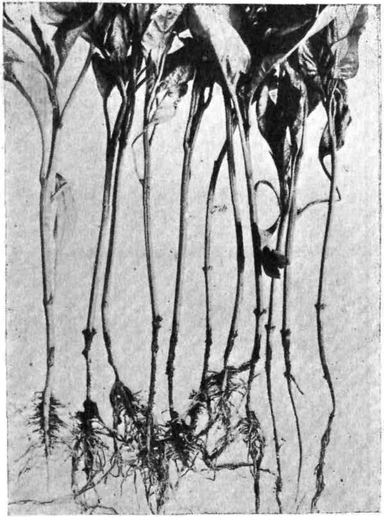


FIG. 1. Pepper seedlings damping off with Rhi…

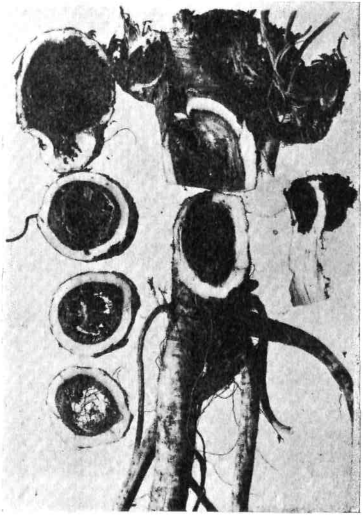
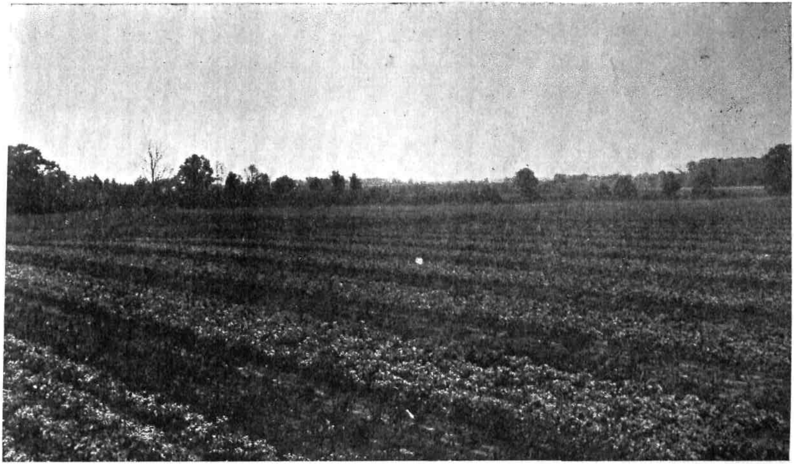


PLATE 5



Potato Spraying Test—Every Other Four Rows Sprayed with Bordeaux Mixture

PLATE 6

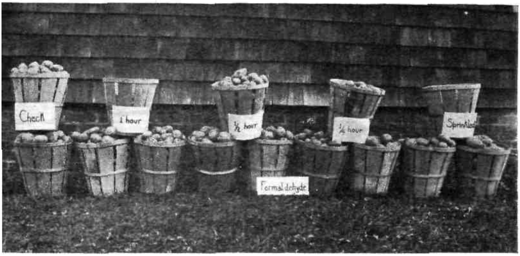


FIG. 1—Yield of Prime Tubers from Seed Treated with Formaldehyde for Scab Control Compared with Yield from Untreated Seed
(From N. J. Agr. Exp. Sta. Cir. 122)

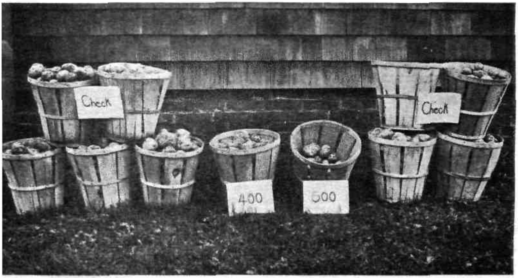


FIG. 2—Unsalable Scabby Tubers from Plots Treated with Sulfur for Scab Control Compared with Those from Untreated Plots
(From N. J. Agr. Exp. Sta. Cir. 122)